A Lean Approach to the Reengineering of an Organization's Processes and Design

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To my mother, father and sister

"It is not necessary to change. Survival is not mandatory."
- W. Edwards Deming (1900-1993)

Resumo

A presente dissertação foi desenvolvida no âmbito da finalização do Mestrado Integrado em Engenharia Industrial e Gestão, pertencente à Faculdade de Engenharia da Universidade do Porto. Este documento foi produzido no decurso de um projeto realizado numa empresa portuguesa cujo negócio se prende com a comercialização de mobiliário e tecnologia associados a espaços laboratoriais. A rápida expansão internacional e diversificação de oferta que a empresa teve nos últimos anos de atividade levaram a um aumento exponencial dos seus problemas operacionais, pelo que se sentiu a necessidade de desenvolver um projeto cujo principal objetivo seria o de identificar e analisar oportunidades de melhoria que pudessem ser implementadas no futuro. Foi adotada uma abordagem *lean*, que assenta numa filosofia de melhoria contínua.

O trabalho foi realizado num período de cinco meses, que foi organizado em fases e objetivos intermédios. A etapa inicial consistiu em fazer o levantamento dos processos e da estrutura organizacional da empresa, através da consulta dos seus procedimentos, de questões colocadas a vários elementos da empresa, e da observação de uma auditoria ao sistema de gestão de qualidade realizada por uma entidade externa. Uma vez recolhida a informação sobre o funcionamento da empresa, procedeu-se à fase de o representar de uma forma visual, usando-se técnicas de modelação dos processos da cadeia de valor e das dependências hierárquicas. O passo seguinte passou por entender as causas de fundo dos problemas observados na empresa, que tendo sido identificadas serviram de base à última etapa do projeto, que consistiu na formulação de medidas de melhoria.

Verificou-se que as dificuldades sentidas pela empresa se deviam essencialmente à ausência de um método simples e sistemático de resolução dos problemas, a uma estrutura organizacional não adequada às recentes mudanças no negócio da empresa, a um mecanismo ineficaz de transmissão e gestão da informação associada à execução do trabalho, e à inexistência de um modelo de melhoria contínua da empresa. Deste modo, foram modeladas sugestões que abordassem cada um destes aspetos, tendo como base a reformulação do sistema de gestão da qualidade atualmente praticado, e a criação de um mecanismo de gestão visual da informação. Por fim, estas medidas foram classificadas quanto à sua relevância, tempo de implementação, custo associado, esfoço colaborativo necessário, e risco, de forma a se indicar quais as que poderiam ser implementadas mais facilmente num horizonte temporal próximo.

A Lean Approach to the Reengineering of an Organization's Processes and Design

Abstract

The present dissertation was developed within the context of the completion of the Integrated Master's Degree in Industrial Engineering and Management, belonging to the Faculty of Engineering of the University of Porto. This document was produced in the course of a project implemented at a Portuguese company whose core business revolves around the commercialization of furniture and technological solutions for laboratory spaces. The quick international expansion and diversification of offer that the company experienced in the past few years led to the exponential increase of operational problems, which created the necessity of developing a project in which the main objective would be to identify and analyze improvement opportunities that could be implemented in the future. A lean approach was followed, which is based on a continuous improvement philosophy.

The project was executed in a period of five months, which was organized in phases and intermediate goals. The initial stage consisted in understanding the processes and organizational structure of the company, through the consultation of its procedures, the informal interviewing of various employees of the company, and the observation of an audit of its quality management system performed by an external entity. After information was collected about the functioning of the company, the phase of its visual representation began, using techniques for modeling its value chain processes and its hierarchical dependences. The next step involved the finding of the root causes of the problems that were observed in the company, that once identified served as the basis for the last phase of the project, which consisted in the formulation of improvement measures.

It was found that the difficulties felt by the company were essentially due to the absence of a simple and systematic method of resolution of problems, the adoption of an organizational structure that is not adequate to the recent changes in the business of the company, the existence of an ineffective mechanism of transmission and management of information that is associated with the execution of daily work, and the inexistence of a continuous improvement model. Therefore, there were formulated suggestions that addressed each of these aspects, having been based upon the reformulation of the currently practiced quality management system, and the creation of a mechanism of visual management of information. Finally, these measures were classified according its relevance, implementation time, associated cost, required collaborative effort, and risk, so as to indicate which of them could be more easily implemented in a near time horizon.

Acknowledgments

The execution of the project that led to the writing of this dissertation would have never been possible without the support and advice of certain people, to whom I am extremely grateful.

In the first place, I would like to thank two key people from the company in which this project was developed, Engr. José Branco and Engr. Rafael Silva, for giving me the opportunity of participating in this project, for making sure I had the best working conditions they could offer, and for kindly granting me a scholarship.

I would like to express my gratitude to Prof. Américo Azevedo and Prof. Eduardo Martins, who were instrumental in the organization and structuring of the dissertation, and whose guidance allowed me to develop new skills and competences, therefore preparing me for the working life. I would like to thank Serafim Araújo, who shared the working experience in this company with me, and who contributed to the development and output of this project as well.

I am grateful to everyone from the company for making me feel at ease and for enabling my integration into the organization. Some of them played an important role in the understanding of the company's problems and, therefore, in the development of the project, namely Engr. Rafaela Ferreira and Engr. Rafael Couto, whom I want to acknowledge for their cooperation.

I express my thankfulness to my family, mainly my parents and my sister, for their unconditional love and support throughout my entire life, without which my personal and academic development would have not been possible.

Last but not least, I would like to acknowledge the love and support of my close friends, who over the years have been filling my life with happy and memorable moments.

Contents

Abbreviations

BMC – Business Model Canvas

BPR – Business Process Reengineering

CT – Cycle Time

ERP – Enterprise Resource Planning

IT - Information Technology

JIT – Just-in-Time

JPF – Jefferson Pilot Financial

KPI – Key Performance Indicator

LEI – Lean Enterprise Institute

LDMS – Lean Daily Management System

LT – Lead Time

MRP - Material Requirement Planning

PDCA – Plan, Do, Check, and Act

PDM – Product Data Management

PR – Problem Registry

R&D – Research and Development

R&D&I – Research, Development, and Investigation

SWOT – Strengths, Weaknesses, Opportunities, and Threats

TPS – Toyota Production System

TT – Total Time

VAT – Value Added Time

VSM – Value Stream Map

5W – Five «Ws»

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1 Introduction

This initial section of the dissertation aims to provide an insight into the context in which the project was developed, its objectives and the methods employed during its course.

In the first place, the circumstances that led to the need for a solution are explained, enabling the definition of the research questions and the project goals. The method explains how the problem was approached, i.e., the way that work was planned and organized. Finally, the structure of this document is briefly presented.

1.1 Project Framework

The project was developed in a Portuguese company whose core business concerns the commercialization and installation of technical furniture for laboratories[1]. Founded in 1998, the company began its activity as a national representative of a large furniture firm, having decided to venture into its own business a few years later. It created its own lines of products and expanded its activity to the development of turn-key projects and cutting-edge technology for intelligent laboratories.

Over the years, the company has gained a significant volume of exports, which led to the establishment of subsidiaries in Angola, Morocco, Switzerland, Mozambique and Cape Verde. Nowadays, its international turnover surpasses the national one. This company is considered to be orientated to services rather than to manufacturing, due to buying and subcontracting most of the material.

Alongside its growing international business, the company has been increasing the dimension of its portfolio of products, by means of offering a wide range of standard and customized solutions. While such flexibility translated into a strong competitive advantage, it also required a big internal effort in order to keep up with the growing complexity and customization of customers' requests. In the past few years, the number of employees has increased significantly, a situation that further complicated the internal coordination.

Taking into consideration these three factors - expansion into international markets, diversification of portfolio and increasing workforce – and the fact that these changes occurred in a short period of time (more or less five years), the company has been experiencing a higher number of errors and problems. Facing these new challenges, it has realized the need to rethink the way its business processes are conducted, and whether it should change its organizational structure, in order to adapt itself to this changing reality.

These circumstances led to the formulation a project in which principles from the lean management philosophy would be applied for the benefit of the company. Using this improvement methodology, the project would comprise three phases: the characterization of the company's business, processes and organizational design; the identification of the root causes of the problems it has been experiencing; and the formulation and analysis of improvement opportunities.

[1] LABORIAL – Laboratory Solutions, S.A.

1.2 Project Goals

Having characterized the general framework of the project, the definition of the goals of its execution constitutes the next critical step. These objectives have not only to be relevant to the necessities of the company, but also to be adequate to the time horizon of the writing of the dissertation, which is about five months.

This project aims to accomplish the following goals:

- Explain how the historical evolution of the company and its strategic choices conditioned their operational performance;
- Characterize, using lean tools, the current business processes and the way that tasks are assigned to employees involved in them;
- Identify and explain the root causes of the problems the company has been facing in recent years;
- Propose a «to-be» model of the organization that addresses the identified root causes of the problems;

This dissertation is structured in a way that enables each of the mentioned goals to be clearly addressed.

1.3 Research Questions

The definition of research questions is critical for the organization of the work required to execute the project. These questions are formulated in a way that ensures that the different phases of the project are in line with the stated objectives.

This dissertation was written with the aim of being able to answer the following questions:

- What types of problems are affecting the company?
- Which root cause(s) is/are at the source of the problems?
- What is/are the bottleneck(s) that is/are conditioning the operational performance of the company?
- Which current aspects could be improved?
- How could the reforms be implemented?

The following section of this first chapter explains how work was planned and organized so that the research questions could be answered.

1.4 Methodology

The project framework implies the understanding of the functioning of the whole company when it comes to its processes, hierarchical dependencies, strategic choices and evolution over the years. The identification of the critical areas and opportunities for improvement requires both a thorough observation of the daily activities of the company and the representation of such activities in abstract thinking models, so that they can be analyzed through unbiased and clear lenses.

Therefore, both empirical and deductive methods were used in this project. The first one was put into practice by informally interviewing and interacting with employees of the company who could provide a useful insight into its daily tasks, and by performing *gemba* walks (*gemba*

meaning «the real place» in Japanese), in which the shop-floor and offices were visited and subject to observation. These two methods enabled the obtainment of qualitative data in form of written descriptions of the relevant facts observed. Another empirical method was used in order to collect data that would validate the qualitative observations. It consisted in data analysis that were run in the company's Enterprise Resource Planning (ERP) software with the aim of quantifying the workload of the key operational activities, the time required to perform them, and the frequency of the occurrence of operational problems.

The deductive methods used in the investigation consisted in the application of tools from two philosophies: lean management and business process reengineering, which are discussed in the second chapter of this dissertation. Such tools are detailed in chapters three and four.

Before structuring the project schedule it was necessary to define its focus, taking into account the three business units of the company: technical furniture, turn-key projects and intelligent laboratories. Following Pareto's Principle of the majority of outputs being caused by few critical factors, it was verified that the reported problems were largely related to the technical furniture business unit, the company's original business and the one that requires a bigger operational effort. Therefore, the project focused on the technical furniture business unit.

In the beginning of the project, the three main phases of its execution were outlined: finding the facts, discovering the causes and formulating measures. The first one consisted in characterizing the current state of the company through the prisms of its processes, organizational structure, task delegation, communication mechanisms, quality system, and technological support. In the second stage of the project, the root causes of the problems identified in the previous stage were discovered and explained. Finally, improvement suggestions were enunciated and analyzed in terms of the benefits and difficulties of its implementation.

1.5 Structure of the Dissertation

This dissertation is structured according to the phases of the project based on which it was written.

After this introductory section comes a chapter dedicated to the review of the state of the art of themes related to this project: the main principles and tools of the lean philosophy (both in manufacturing and services businesses), the concept of process reengineering work, the foundations of change management, and the different conceptions of organizational structure.

The third chapter comprises the first and second phases of the project and is structured in four sections: an analysis of the company's business and overall performance over the years; a general and a detailed modeling of its processes and task assignments; a critical look at its organogram; and the identification of the root causes of its problems.

The fourth chapter reflects the final stage of the project, i.e., the suggestion of improvement actions concerning the following change dimensions: organizational redesign, creation of a visual management, reengineering of core processes, and reformulation of the quality system. These are complemented with additional considerations and a brief analysis of the pros and cons of its implementation.

Finally, chapter five refers the conclusions of the project and future work recommendations, which expose the implications of the continuity of this project.

2 Theoretical Background

This chapter presents an overview of the state of the art of the relevant topics of the dissertation, which can be translated into the following keywords and concepts: lean management, business process reengineering, organizational design, and change management.

To conduct this kind of research, a variety of sources was consulted, including books, articles, webpages, and dissertations. The results of the investigation were divided into four sections according to the different themes in which the dissertation is based upon.

The first subchapter introduces the historical background of the lean management philosophy and its core principles. In the second subchapter, it is explained how the lean concept in manufacturing industries and services companies may differ, which is an important question taking into consideration that the company being analyzed is services-oriented, and that lean management is usually associated with manufacturing industries. The third section explains the concept of business processes reengineering, which is related to the one of organizational change, and the final one mentions the varied conceptions of organizational structure.

2.1 The Roots and Main Principles of Lean

The concept of lean management is widely used in today's business panorama. It often appears in different contexts and situations, which may lead to confusion about its meaning and scope. Therefore, it is important to explain how it was originated and its main principles.

The term «lean» was created in the 1980s by a research team in the United States of America. It is a concept that derives from the Toyota Production System (TPS), developed in the years after the Second World War at Toyota Motor Company, today's largest car manufacturer in the world. The key figures behind TPS were Kiichiro Toyoda, the founder of the company, and Taiichi Ohno, an engineer who worked there. At the time, the most advanced production system was the one developed by Henry Ford, who is considered the father of mass production (Lean Enterprise Institute [LEI], 2015a). Ford was able to increase the flow of products by implementing the first moving assembling line on the shop floor, but he could not diversify the range of products. Ohno managed to overcome this problem by applying the concept of demand driven production, "(…) right-sizing machines for the actual volume needed, introducing self-monitoring machines to ensure quality, lining the machines up in process sequence, pioneering quick setups so each machine could make small volumes of many part numbers, and having each process step notify the previous step of its current needs for materials (…)" (LEI, 2015a). This production system reduced the lead time of products, i.e., the time it takes to process them, and increased product variety. Ohno published the book *The Toyota Production System* in 1978, but it was only with the publication of *The Machine That Changed the World* (1990) by James P. Womack, Daniel T. Jones and Daniel Roos, that the western world gained consciousness of this emergent management mindset.

In lean literature, the book *The Toyota Way* (2004) by Jeffrey K. Liker indicated the principles behind TPS. According to Lean Blitz Consulting (2015), the principles described in this book are based upon the concepts of continuous process flow, visual management, first-time quality, empowerment of employees, and continuous improvement. This new approach to management was very different from the previous ones, because it focused on the flow of the entire productive process instead of trying to improve the performance of each machine, step or department individually. The work became demand driven, and the main goal was to create

value for the costumer, thereby improving production quality and eliminating everything that did not add value to the customer, i.e. waste.

Figure 1 is a representation of the TPS House, a visual depiction of the core values and objectives of this management philosophy. The goals of high quality, low cost and short lead times are achieved through the implementation of Just-in-Time (JIT), *Jidoka* (which means «autonomation»), *Heijunka* («production leveling»), standardized work, and *Kaizen*, which can be translated to «change for better».

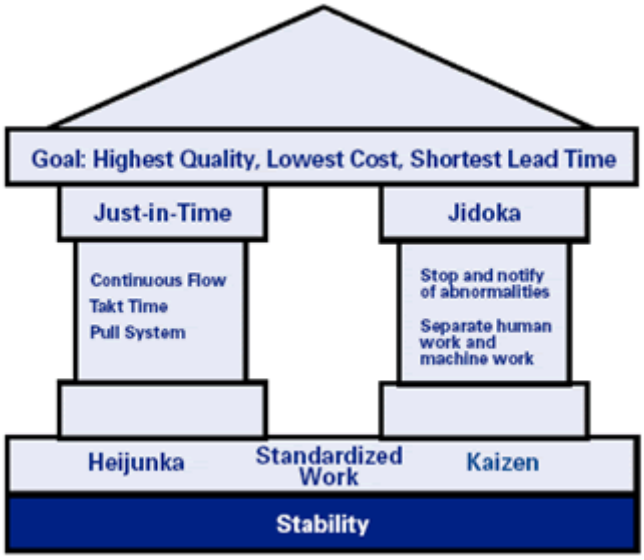


Figure 1- The Toyota Production System House (LEI, 2015b)

While Lean is focused on cutting waste, *Kaizen* is more of a continuous improvement philosophy, therefore acting as a basis upon which lean tools are implemented, such as JIT and *Jidoka* (Walters, 2013). The first one is a production mechanism contrary to mass production, because it limits production to the exact quantity that the customer needs, preventing unnecessary stocks and requiring that resources are able to react quickly to demand shifts. The latter consists in an automatic quality control mechanism that interrupts the process flow each time an error is detected, in order to immediately act upon it and identify its route cause, thereby preventing that the same mistake happens in the future.

The lean methodology consists in "(…) improving the flow of activities and reducing the cost of a process by reducing several forms of waste" (Harmon 2007, 342). According to the traditional view of lean, which is focused on manufacturing, there are seven types of waste, which are described as follows:

- Overproduction – when it is produced more output than what is needed by the downstream process;
- Waiting – when an upstream process takes more time than usual to deliver inputs to the following process;
- Transport – when materials are unnecessarily moved from one place to another;
- Extra Processing – when extra work is applied to products, without it being requested by the customer;
- Inventory – when raw materials or finished goods are stored and not used to satisfy the customer's request;

- Motion – when employees have to move excessively when accessing the tools they need to perform their work ;
- Defects – when products are damaged and need to be reworked or replaced (Harmon 2007, 345-346).

2.2 The Emergence of Lean Service

The previously mentioned types of waste are more common in manufacturing companies. Over the years, there has been a growing interest in trying to understand how lean can be adapted to service companies, despite the common belief that it is only applicable in manufacturing settings. According to LEI (2015c), lean "(…) applies in every business and every process (…)", because it (…) is not a tactic or a cost reduction program, but a way of thinking and acting for an entire organization". Therefore, authors and managers have written a variety of articles and books about the services perspective on lean thinking.

According to Swank (2003), lean manufacturing principles can be applied to service companies, as it was the case of Jefferson Pilot Financial (JPF), a full-service life insurance and annuities company from the United States of America that, at the end of the 1990s, was struggling to keep up with a competitive market and higher costumer expectations. This company realized that it could become more competitive if it improved the performance of its operations, by reducing lead times and the percentage of rework. JPF noticed that its product – insurance policies – underwent a series of processes in a continuous flow that greatly resembled the one of physical products in assembly lines. Therefore, the company investigated the case of manufacturing companies that managed to improve its performance by applying the lean manufacturing principles of Japanese companies after the Second World War. The first step in the lean program was to build a model cell, a physical space in which the entire operational process was represented and performed, so that it could be monitored and improved. In this model cell, seven lean manufacturing principles were tested:

- Consecutive processes are placed next to each other – this principle reflects the notion that improving operations requires improving the flow of the processes, not the performance of each function or department;
- Work procedures are standardized – by standardizing work procedures, it is easier to exchange tasks between employees and to evaluate their performance;
- Loop-backs are eliminated – delays occur when products return to a previous resource to be processed, and an extra effort is required to manage time and tasks within the overused resource;
- Work is adjusted to the demand rate – by determining the rate of demand it is possible to condition the rhythm of work so that downstream processes are not waiting for the output of the upstream ones;
- Work is distributed equally by resources – tasks are delegated in a way that no resource is more occupied than any other at any time, thus reducing waiting times between processes;
- Work is divided according to complexity – if certain tasks require different levels of complexity and distinct procedures, it is better to separate them so that resources are used to their maximum potential;

- Visual management is applied in performance monitoring – when information about outputs and performance metrics are displayed in a clear way for all employees to see, there is a better notion of the progress of work, and workers are encouraged to improve their performance.

By applying these lean manufacturing principles, JPF was able to reduce the lead times of its operations and the percentage of errors and rework, therefore cutting costs and increasing revenues. Another important lesson can be taken from this example, concerning the way that performance metrics were defined. Instead of focusing on departmental or functional performance, they reflected the customers' point of view, therefore motivating employees to improve the output of the entire process and not just of what is directly related to their tasks.

It is worth mentioning another lean service related article, which introduced and described the idea behind Lean Consumption, stating that it "(…) isn't about reducing the amount costumers buy or the business they bring. Rather, it's about providing the full value that consumers desire from their goods and services, with the greatest efficiency and least pain." (Womack and Jones 2005). This concept implies that in order to optimize service operations, the point of view of the customer has to be adopted. The authors outlined the principles supporting Lean Consumption, which were further detailed in their subsequent book "Lean Thinking", published in late 2005. They were defined as follows:

- The customer's problem has to be completely solved – this implies that help services need to be able to identify patterns in customers problems, thus acting on its root causes rather than providing quick fixes;
- The customer's time has to be reduced – by mapping the steps the customer has to take when being attended, it is possible to think how the process can be remodeled in order to reduce the amount of time in which value is not being added to the customer;
- Offer exactly what the customer wants – this idea goes hand in hand with the one of demand driven production supported by lean thinking, i.e., the pull replenish method in which the customer is provided with only what is needed;
- Offer exactly what the customer wants where it is wanted – this means that there are appropriate channels of distribution for certain services or products;
- Offer exactly what the customer wants where and when it is wanted – this idea takes into account that customers may not want to decide every detail of their order in the beginning of the purchasing process;
- Incorporate integrated solutions to customers' problems – instead of focusing on one side of the problem, service provides should try to cover every aspect of it, thereby completely satisfying the customer.

The implementation of the lean philosophy in service companies has proved to be successful, although it has also been misused in some cases. In an attempt to apply lean manufacturing to services, some managers have treated internal processes as production steps in an assembly line logic, only to find out that they were not improving. This happened because in order to "(…) make the fundamental change that moving from the present style of management to managing the organization as a system requires managers first to understand their problems" (Seddon *et al*, 2009). This means that before choosing the lean tools to be implemented, managers need to understand the root causes and nature of the problems they are facing, because each service company operates in a specific context under distinct conditions. Therefore, there should be

given more attention to lean management than to its tools. Service companies may be better understood if there is a distinction between value demand and failure demand, the first being related to every customer demand that justifies the purpose of the company, and the latter referring to requests made by customers whose initial requests were not fully or correctly satisfied. Failure demand consists in a very big form of waste for service companies, which is the result of them being treated as manufacturing cells by managers. The two main causes of failure demand are functional specialization and standardization, which leads to a company being unable to lead with variety in demand, a common characteristic in services. Instead of aiming to cut costs by standardizing procedures, managers should try to create value for the company by training employees to deal with volatility in customers' demand (Seddon *et al*, 2009).

Failure demand represents just one aspect of waste in service companies. Very often, waste in office environments is not obvious, neither is its impact on profitability. "The waste is the cost of lost business, damage control efforts, lost opportunities that could not be pursued because of the problem, and the diversion of management attention from the critical tasks of planning, leading, and relating to customers" (Lareau 2003, 20). According to this author, waste in office environments occurs even in successful companies, and it is a threat to competitive advantage. Two big groups of waste are identified: surface and leadership waste.

Figure 2 introduces the four parameters supporting leadership in a company: focus, structure, discipline and ownership.

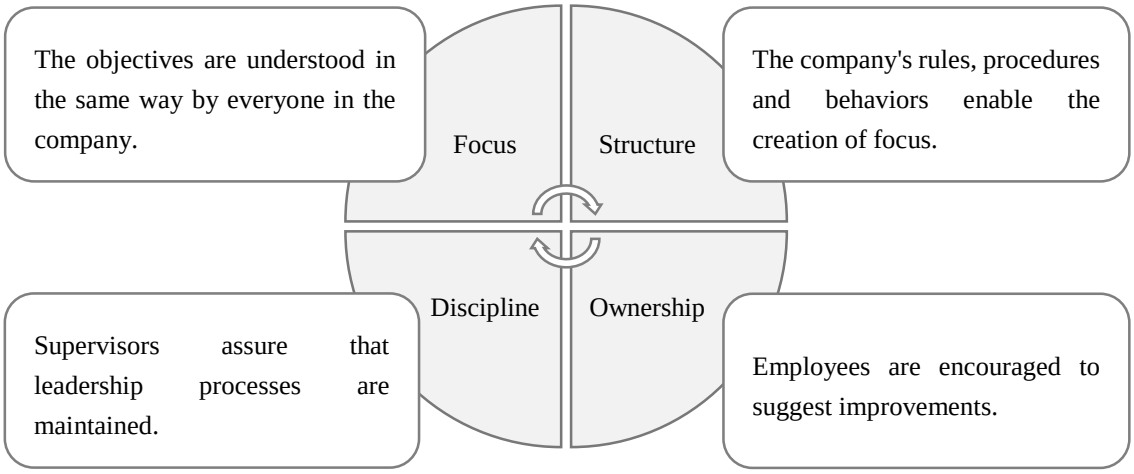


Figure 2 – Four Leadership Parameters (Lareau, 2003)

In order to have a successful leadership in a company, it is necessary to eliminate waste coming from lack of focus, poor structure, and insufficient discipline and ownership. These types of waste usually occur in the following situations:

- There is a lack of focus – the vision and goals of managers are not well communicated to the different levels of the company, leading to confusion in different work groups of the company about how the objectives can be achieved;
- The structure is weak – the processes and way of working of employees are not well defined and standardized across the different departments and divisions of the company, making it difficult to attain the objectives outlined by the focus;
- There is not enough discipline – leaders are not providing regular feedback about the performance of daily activities, there is not a quick and effective reaction by supervisors

whenever employees make mistakes, support and training are not provided to workers when it is necessary;

- There is not a sense of ownership – employees are not encouraged to suggest improvements or to solve internal problems by themselves, leading to excessive control by supervisors and demotivation of workers.

Once leadership waste has been tackled, it is possible to remove surface waste, consisting in "(…) resources consumed by activities that do not add value to a product or service (…) from the perspective of the customer" (Lareau 2003, 21). These types of waste are related to four dimensions: people, processes, information, and assets.

Figure 3 provides a brief explanation of what characterizes each type of surface waste, which are described by Lareau (2003) as «silent killers», i.e., waste that may go unnoticed in a company and cause a great damage to its competitive advantage.

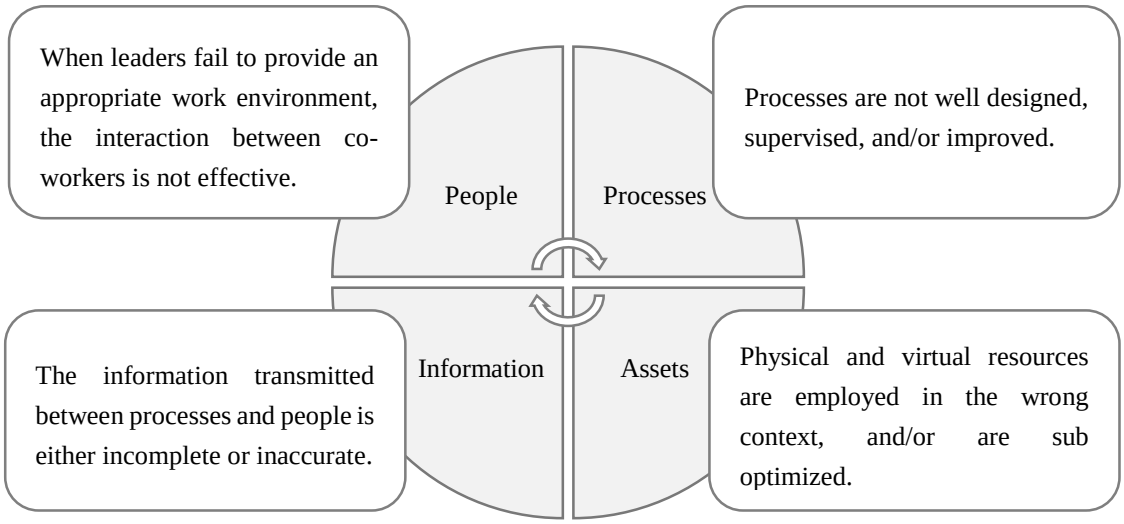


Figure 3 – Types of Surface Waste (Lareau, 2003)

Surface waste comes in the form of people, processes, information and assets, which happen when the following circumstances take place:

- Interaction between co-workers leads to waste – this may occur when employees have to wait too long for a piece of information or the completion of a previous activity in order to start working, when work is not well performed due to lack of training, or when workers are assigned to irrelevant and/or unnecessary tasks;
- Processes are not well designed, which leads to non-optimal performance –excessive supervision of work, trying to change a process without thinking of all possible consequences, excessive focus on short-term needs, non-standardization of working procedures, or the use of informal work methods instead of the official ones;
- Information flow is not clear – when information is processed in different ways while being transmitted between employees and departments, when there are missing or wrong details in the information, or when it is manipulated in order to project a favorable image of one's performance;
- Assets are not used in an optimal way – resources employed in operational bottlenecks create more work-in-process, fixed assets that are not used to their maximum capacity may require an unnecessary investment in additional space.

By tackling both leadership and surface waste, companies are able to respond to changing markets and growing competition.

2.3 Business Process Reengineering and Change Management

Business Process Reengineering (BPR) is a management strategy that originated in the 1990s. It is generally considered that the creator of such strategy is Michael Hammer, who in 1990 published the revolutionary article "Reengineering Work: Don't Automate, Obliterate" in Harvard Business Review. In this article, Hammer described BPR as a work that "(…) strives to break away from the old rules about how we organize and conduct business" (Hammer, 1990). Therefore, a company needs to rethink its traditional structure and mechanisms if it wants to implement BPR. Such radical changes are necessary in order to shift the focus on cost and control to quality and innovation, so that companies are able to adapt themselves to increasingly competitive markets (Hammer, 1990).

BPR requires a cross-functional view of business, an understanding of how a company creates value to its customers. By modeling the current state of its processes - the «as-is» process diagram – it is possible to have a clear view of how product or service flows through the processes, enabling the detection of opportunities for improvement, which are represented in the «to-be» process diagram (Harmon 2007, 248).

This cross-functional view of business consists in one of the main principles defended by Hammer (1990), who advocates the integration of tasks rather than specialization, therefore making people less focused on their individual work, and more aware of the outputs of the entire process. Other core idea behind BPR concerns the incorporation of control mechanisms into the process itself, so that workers doing their job are also responsible for monitoring its quality, rather than having other employees supervising their work (Hammer, 1990). Finally, it is recommended the use of coordination mechanisms while dealing with parallel activities and geographically dispersed resources, and the standardization of communication channels. (Hammer, 1990).

BPR needs to be applied very carefully due to its radical nature. According to Bergey *et al* (1999), there are common mistakes that companies make while trying to transition from a legacy system (the current mechanisms and rules applied by the organization) to the target system:

- The wrong problem is addressed;
- Not all steps of the reengineering process are performed;
- Consultants and/or contractors are hired without a clear definition of their roles within the company;
- The worked force does not receive the necessary training in order to be able to perform new tasks;
- There is little or no documentation about the legacy system that may help decision making, such as information about historical evolution and indicators of the required time, capacity, and money to make certain changes;
- The requirements of the target system are not well defined and/or validated by key stakeholders of the company;
- The legacy system architecture is not well understood;

- The reengineering plan does not have clear goals and milestones, and responsibility is not well defined;
- There is a lack of long-term commitment by managers supervising the reengineering effort;
- Managers define the reengineering project rollout without consulting the project team members, and/or base their decisions in hunches.

BPR is one of the ways through which change can be implemented in an organization. This type of effort takes time and has to be thoroughly structured, monitored and understood by everyone involved in it. To implement it successfully is a big challenge. According to Kotter (2007), there are eight steps in a change program within a company which have to be followed in the correct order, and avoiding common mistakes in each one of them. They are described as follows:

- People in the company need to understand why it is urgent to change the status quo, and should avoid resistance based on fear of risk taking;
- There should be formed a change project team that clearly understands the plan, whose members interact well together and whose leadership is delegated to an operational manager, due to having a clear notion of the problems the company is facing;
- There has to be created a vision for the change project, one that is easy to communicate and to be understood;
- The vision has to be communicated through every possible channel, and the project team should be the reflection of that vision through its actions, words and behaviors;
- After communicating the vision, the project team has to assure that all obstacles to change are removed, and that innovative ideas are encouraged;
- There should be planned short-term wins in less than a year, in order to compensate people for their effort and to show them that change is possible;
- Once short-term goals have been achieved, it is important to identify new opportunities for improvement, hire and/or develop people to implement the change vision, and not to declare victory too soon by abandoning the change program;
- In the long term, once changes have proven to be successful, managers have to institutionalize new values and practices that translate the vision, and assure the continuity of leadership.

2.4 An Overview of Organizational Design and Structure

The concept of organizational design is not an obvious one, for it may be confused with other terms that are related to the way that companies distribute tasks between employees and organize internal work. According to Jones (2002, 10), organizational design is "(…) the process by which managers select and manage aspects of structure and culture so that an organization can control the activities necessary to achieve its goals". Therefore, it is through organizational design that companies model its structure and disseminate values through employees, which in the long-term leads to the formation of patterns of behaviors within the organization.

Structure reflects the way that roles and responsibilities are attributed to employees, how workers are grouped in teams and departments and the authority relationships between them.

Culture translates into the ethics, values and norms of an organization, i.e., the way employees deal with internal and external situations.

Organizational design is not an easy and clear-cut process, as it requires the analysis of the company's profile and the external environment in which it operates. Choosing a certain type of structure usually requires a trade-off between competitive advantages. These trade-offs appear in the form of challenges the company faces while trying to balance its levels of differentiation versus integration, centralization against decentralization, and standardization versus mutual adjustment (Jones, 2002).

Differentiation reflects the division of labor within a company, the degree to which its workers are specialized in distinct departments and functions. It can happen in both vertical and horizontal dimensions, the first referring to the creation of hierarchical levels and authority relationships between them, and the latter consisting in the definition of roles and functions, such as the formation of teams and departments. While increasing specialization enables the development of competitive skills, it may also lead to communication problems between workers and departments. According to Jones (2002, 104), different types of mechanisms may be employed to reinforce integration within a company. They are described as follows:

- Hierarchy of authority – this consists in the traditional mechanism of vertical differentiation;
- Direct contact – this happens when people meet face-to-face to discuss issues;
- Liaison roles – in each department a worker is given the role of coordinating interaction between his/her department and the others;
- Team or task force – managers get together in regular or temporary committees (respectively) in order to debate cross-functional issues;
- Integrating role or department – a role or department (respectively) is specifically created with the purpose of coordinating communication between managers of different divisions/departments.

Figure 4 demonstrates how vertical and horizontal differentiation are reflected in an organizational chart. Vertical differentiation occurs with the creation of hierarchical levels, in which the second level reports to the first, the third to the second, and so on. Horizontal differentiation happens when new functions are created at the same level, increasing work specialization.

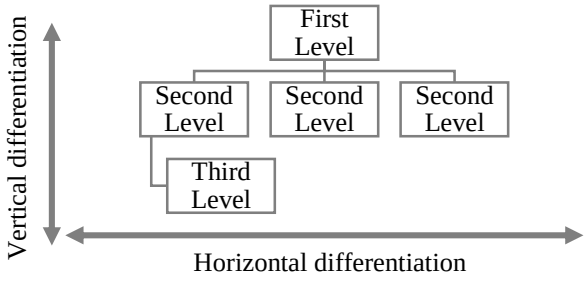


Figure 4 – Vertical and Horizontal Differentiation (Jones, 2002)

Another important concept related to organizational design is that of span of control. It refers to the number of employees that a superior manages directly, which depends on the complexity and interrelatedness of the tasks they perform. When work is complex and workers are highly dependent on each other, it is difficult for a superior manager to supervise their work. The web of interaction is too wide for just one supervisor, and loss of control of employees is a natural consequence (Jones 2002, 138-139).

The balance between differentiation and integration, centralization and decentralization, standardization and mutual adjustment, and the definition of the span of control lead to various possibilities of organizational structure.

There are four major types of organizational structure, each functioning in a distinct way and presenting potential advantages and disadvantages once implemented in a company. Four types of structure are further explained: functional, divisional, multidivisional, and matrix.

2.4.1 Functional Structure

In a functional structure, employees using the same resources or doing the same type of tasks are grouped (e.g.: Manufacturing, R&D and Finances are distinct functions).

It has the advantage of helping to increase specialization, technical skills and know-how, but it may lead to coordination and communication problems between functions (Jones 2002, 160-164).

2.4.2 Divisional Structure

In a divisional structure, divisions are created in order to answer to specific requirements of products (goods or services) offered by a company, locations where it is present, or groups of customers it serves. There is also a centralized set of support functions (e.g.: finances) that provides support to all divisions. Managers operating in divisions are at the divisional level of management, and those at support functions belong to corporate management. Divisional managers are subordinates of corporate managers.

This kind of structure has the advantage of helping to develop specialization in a way that a company is better prepared to deal with specific requirements in its business. However, it is only adequate to a company operating in one business (Jones 2002, 167-169).

2.4.3 Multidivisional Structure

In this structure, there are divisions and corporate head staff like in the divisional structure, with the difference that each division has its own set of support functions. Managers in these support functions are at the function level of management. Therefore, in multidivisional companies there are three levels of management: corporate, divisional and functional, in which functional managers report to divisional ones, who in their turn are subordinated to corporate-level managers.

Unlike divisional structures, this one is adequate to a company operating in different businesses. It increases both differentiation and integration, because it is possible for each division to have its own functional structure while at the same time being coordinated by a central corporate management. Therefore, there is the disadvantage of arising conflicts between corporate and divisional managers, and of poor communication between divisions (Jones 2002, 170-176).

2.4.4 Matrix Structure

The company's structure has a vertical dimension and a horizontal one. Vertically, there are functional roles (e.g.: purchasing), and horizontally there are business teams (e.g.: product division). This means that each worker has to report to two supervisors: the functional manager, and the team manager.

This cross-functional approach helps to reduce functional barriers, and facilitates the internal rotation of employees between roles, which leads to greater flexibility. On the other hand, the existence of two bosses per employee may lead to confusion about who exerts more authority, therefore compromising the decision-taking process (Jones 2002, 183-186).

3 Current State of the Problem

In this chapter, the current situation of the company is analyzed through four dimensions: the performance of its business, the functioning of its business processes, its organizational structure, and the systematic causes of the problems it has been facing. Each dimension is characterized and analyzed in different sections of this chapter. The facts of the current situation are the basis for the formulation of the proposed changes for the company.

3.1 Business Analysis

Two tools are used to qualitatively characterize the business of the company: a Business Model Canvas (BMC) and an analysis of its strengths, weaknesses, opportunities and threats (SWOT).

It is made as well a quantitative analysis in terms of the evolution of the revenue of the company and its level of internationalization.

3.1.1 Business Model Canvas

A BMC is a powerful tool used when trying to characterize a startup business or an already existing one. It is a strategic method of characterization because it helps managers to decide how to conduct their business and how to form a strong network of alliances. These strategic decisions are reflected in nine building blocks, which should be defined in the following logical order:

- Customer Segments – the types of customers the company wants to serve, and whether their needs are distinct from each other;
- Value Propositions – what the company is willing to offer to each segment of customers in order to satisfy the identified needs;
- Channels – which channels the company employs in order to deliver its value propositions to customers;
- Customer Relationships – how the company keeps customers satisfied and loyal over time;
- Revenue Streams – how the company generates revenue by offering its value propositions;
- Key Resources – which assets and infrastructures are crucial to deliver the value propositions;
- Key Activities – which activities does the company need to excel at in order to deliver the value propositions;
- Key Partnerships – the web of strategic partners that a company must develop so as to be able to outsource resources and competences that are out of its core business;
- Cost Structure – the kind of costs that are intrinsically associated with the performance of the key activities (Business Model Generation, 2015).

A BMC was developed to explain the business model of the company. It can be consulted in Annex A. The most important aspects represented in the BMC are synthesized in the following ideas:

- There are three business units in the company: technical furniture (its core), turn-key projects and intelligent laboratories, each offering a distinct value proposition;
- The three value propositions serve the same type of customer (industrial companies in the laboratory and health clusters), each with different needs;

- The order winners that keep customers loyal to the company are the flexibility in the product offering, the quick response to requests, and the lower prices compared to those practiced by competitors;
- Customers are reached through commercial managers in headquarters and subsidiaries;
- The activities intrinsically associated with the company's businesses are sales management, budgeting, outsourcing, and technological development in the case of intelligent laboratories;
- These key activities require key resources like a deep knowledge of market characteristics and tendencies, and technological know-how;
- These resources are developed with the help of strategic partners like suppliers and educational institutions;
- The majority of costs supported by this mainly-services company are related to the outsourcing of material, equipment, and engineering/technical services;
- The revenue streams come mainly from commissioned projects from international markets.

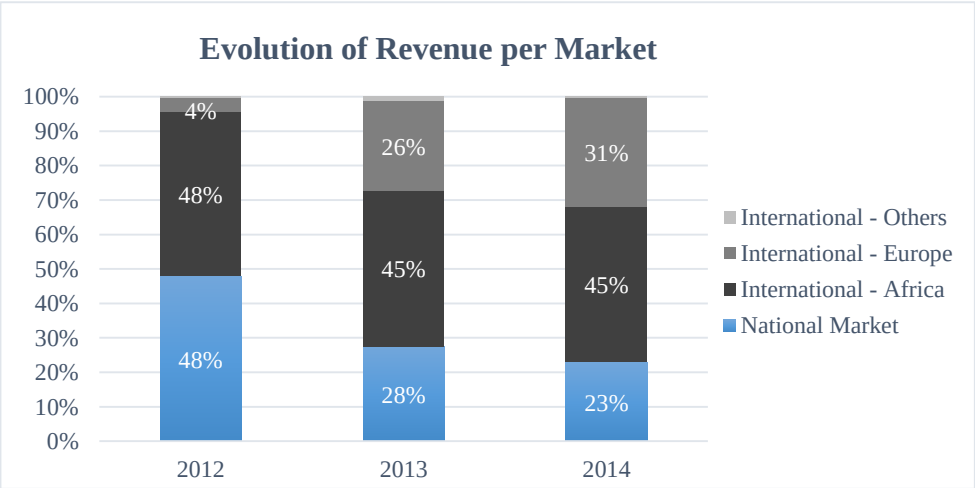
3.1.2 SWOT Analysis

A SWOT analysis is tool used for the assessment of a company's current situation. It characterizes both the internal and external environments in which a company operates, by highlighting the strengths and weaknesses inherent to its activity, and the opportunities and threats that the surrounding context presents.
Annex B contains a SWOT analysis of the company that is being analyzed.

3.1.3 Evolution of Turnover and Workforce

Since its foundation in 1998, the company has significantly changed the level of customization and variability of the solutions it offers to its customers. Alongside this portfolio expansion, the company has been increasing its revenue streams from international markets and has quadrupled its number of employees in a ten year time horizon.

Graphic 1 is an overview of the company evolution in the past few years (from 2012 to 2014), in terms of national and international revenue.

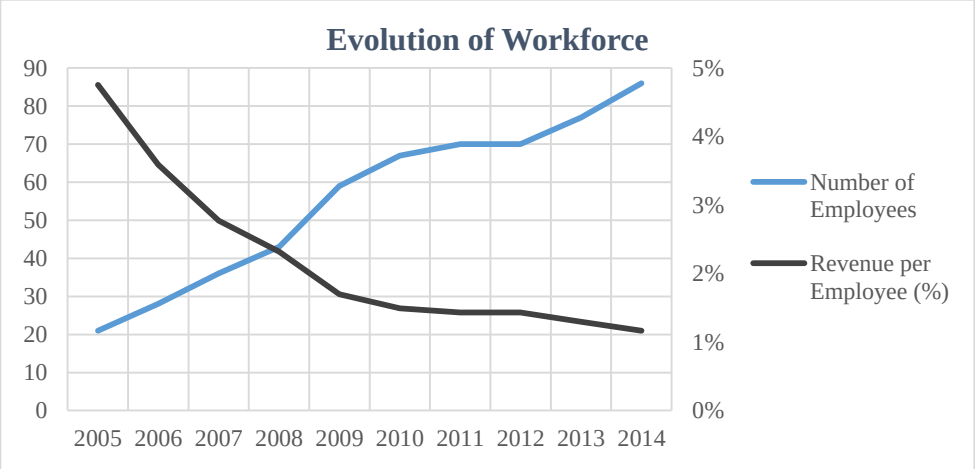


Graphic 1 – Evolution of Revenue per Market

It is evident from this graphic that the company has reshaped its range of customers in the past few years. Once strictly oriented to the national market (from 1998 to 2009), it is now covering five continents: Europe, North America, South America, Asia, and mainly Africa. It has

established subsidiaries in Angola (2010), Morocco (2012), Switzerland, Mozambique, and Cape Verde (all of them in 2013). These subsidiaries consist in teams of commercial managers, which means that all operations remain centralized in Portugal.

In order to keep up with more demanding markets and to coordinate activities between subsidiaries and headquarters, it was necessary to hire new employees and to subsequently restructure departments and functions within the company. Graphic 2 demonstrates the workforce growth from 2005 to 2014, and how the revenue per employee has been slowly decreasing, despite the increase in the number of employees.

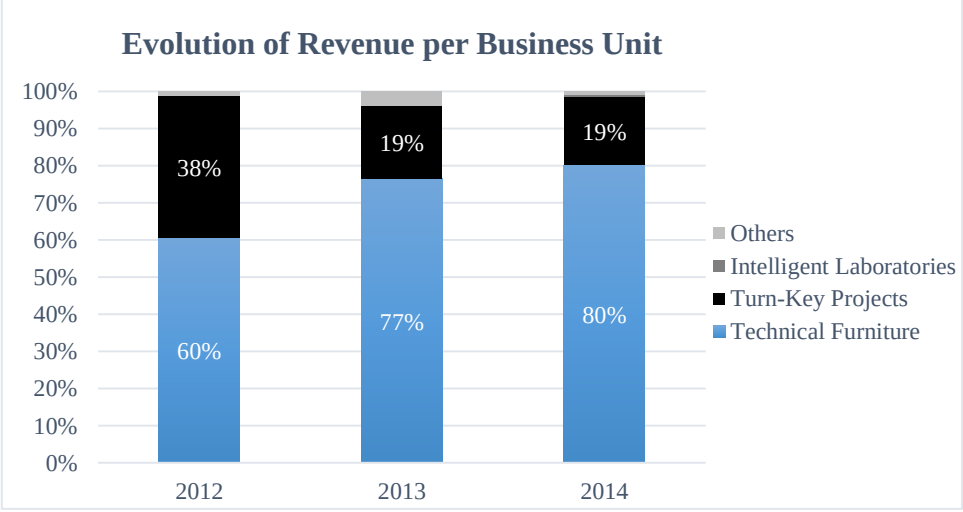


Graphic 2 – Evolution of Workforce

Since its foundation, the company's core business is the commercialization of technical furniture for laboratories. Turn-key projects became a business unit in 2005, and intelligent laboratories in 2011. The company also operates in the business of maintenance contracts and specialized technical services, although on a very small scale.

In the last few years, the revenue generated by the technical furniture business has been increasing, and the one coming from turn-key projects has decreased. Despite having more operational problems than the turn-key projects, there are significantly more technical furniture projects than turn-key ones.

Graphic 3 shows how revenue was generated from 2012 to 2014.



Graphic 3 – Evolution of Revenue per Business Unit

3.2 Business Process Modeling

Once the company's business has been characterized, it is important to understand how its operational processes flow, i.e., how the company internally operates in order to create value for its customers.

In this subchapter, the business processes of the company are analyzed in two phases, first in a general way, and then following a detailed and quantitative approach.

3.2.1 First-level Analysis

A business process is generally defined as a set of tasks that start with a specific input, and that once performed generate an output, which is the input of the following process. Therefore, it represents the flow of products and/or services across all departments and functions of a company. The representation of activities in the form of interrelated and cross-functional processes consists in a business process map.

A business process map makes a distinction between core processes, management processes and support processes. Core processes are the ones which are part of the value chain, i.e., that contribute to the flow of the product/service from the point when it starts to be developed (usually, at a customer's request), up until the moment it is delivered to the customer. Therefore, these processes add value to what is being offered. On the other hand, support processes are not directly related to the value chain. Their role is to assure that core processes function over time. Management processes are related to the control and monitoring of core processes, and to strategic decision-making (Harmon 2007, 86).

In order to develop this first-level analysis, it was conducted an empirical research of the company's processes, whether through *gemba* walks or by directly questioning employees about their daily functions.

The value chain of the company being analyzed is represented in Annex C. The following core processes were identified:

- **Elaborate Proposal** – the process is trigged by a request from a customer, involves a set of activities related to the negotiation of a budget, and delivers a proposal report once the budget has been approved;
- **Receive and Validate Project Proposal** – the process starts once the proposal report is communicated internally, consists in making a first rectification of the approved budget, and delivers the rectified budget;
- **Prepare and Plan Work** – the process begins with the insertion of the approved project in the dispatch plan, involves the planning of the dispatch and installation, the technical treatment of project specifications, the planning of production, stock picking, and purchase orders, and delivers these orders;
- **Execute and Control Work** – the process is triggered by the reception of production, stock picking, and purchase orders, consists in executing these orders, monitoring on-going projects, preparing the dispatch, and delivers separated and packaged materials and equipment;
- **Dispatch and Install Project** – the process starts with the predefined dispatch date, involves the transportation of packaged materials and equipment for the construction site and subsequent installation, and delivers a final inspection of the installation work.

The management processes of the company are defined as:

- **Develop Business Strategy** – plan and monitor the implementation of strategic decisions related to the three business units;
- **Develop Research, Development, and Investigation (R&D&I) Processes –** plan and monitor processes related to research, development, and investigation;
- **Develop Sourcing Strategy –** plan and monitor the implementation of strategic decisions concerning the selection and evaluation of suppliers and business partners;
- **Develop Marketing Plan** – plan and monitor the implementation of a marketing plan indicating the positioning of the company in the market in which it operates, and manage the relationships with customers, suppliers, and other key stakeholders;
- **Develop Quality System** – plan and monitor a quality system that promotes a continuous improvement culture.

Finally, the core processes of the company are backed up by the following support processes:

- **Develop Human Resources** – provide adequate training and support to employees;
- **Control Finances** – assure the financial health of the company by managing cash flows and financial investments;
- **Control Accounting** – monitor the costs and revenues of the company;
- **Maintain Information Technology (IT) System** – make hardware updates and assure that the software is adequate to the requirements of the company business.

Once core, management, and support processes have been described, it is necessary to identify who performs them, and what kind of responsibility is attributed to each functional role. The stakeholders involved in the core processes are represented through the following roles:

- **Project Managers** – they deal directly with the client by analyzing their request and negotiating conditions with them, acting as an interface between the client and the rest of the company;
- **Estimators** – they make budget proposals once project managers have identified the customer's requirements;
- **Project Technicians** – after the customer has approved the budget, they work on specific technical details of the project, such as the rectification of measures (two technicians are assigned to do this), the elaboration of technical drawings for production (a task specifically performed by a distinct technician), and the management of net necessities (executed by a separate technician);
- **Purchasers –** they send and control purchasing orders issued by the project technician responsible for the management of net necessities;
- **Warehouse** – the warehouse comprises employees responsible for production, stock picking, and reception of purchased items;
- **Chief of Operations** – this functional role supervises the work of project technicians, purchasers, and warehouse employees;
- **Developers** – they are responsible for the development of new solutions for the company's technical furniture portfolio, and for assisting project technicians whenever doubts arise about a line of products they have developed;
- **Construction Supervisor** – this figure makes a first rectification of the approved budget before it is handed to project technicians (due to having a significant working experience), decides the date of dispatch and the assembly team, and controls the state of projects that have been already dispatched;

- **Assembly Team** – this team is responsible for the transportation of materials and equipment to the construction site, for assembling them according to the project plan, and for making a final inspection once work has been completed.

After the identification of the core business processes and the key roles of employees, it is necessary to understand how responsibility is delegated to employees in each core process. This information is represented in annexes D to H in the form of responsibility matrixes.

A responsibility matrix is a tool used to visually represent the type of responsibility attributed to each stakeholder at every activity in a process. The levels of responsibility are defined in four ways:

- Responsible – an employee is assigned to perform an activity;
- Accountable – an employee is accountable for the success or failure of an activity, whether he/she was defined as responsible for it as well;
- Consulted – an employee is not directly involved in the performance of an activity, but can be consulted by responsible and accountable employees whenever doubts arise during the course of the job;
- Informed – an employee should be informed of the state and/or outputs of an activity, for it may condition his/her job.

The responsibility matrix of each core process describes the main phases and activities that it contains. It is identified which stakeholders are responsible, accountable, consulted, and/or informed in each activity of the process. By consulting the referred annexes it is evident that three activities are crucial in the value chain of the company. They are identified as Activity 1, Activity 2 and Activity 3. The first two activities ("Elaborate Budget Proposal" and "Make Technical Treatment") are worth noting because they require the collaboration of many stakeholders, therefore demanding an extra effort of communication and team work. The third activity ("Control On-Going Projects") is important to analyze because no employee is assigned the role of accountable. These activities are further analyzed in the next subsection.

3.2.2 Second-level Analysis

A second-level analysis of the entire value chain of the company is made through the representation of its physical and communicational flows in a value stream map (VSM). In a VSM, the core business processes of a value chain are represented in a broad way in order to highlight how material and information flow through them, from the point when the customer places an order until its delivery. Due to its high-overview perspective, the drawing of VSM enables the detection of waste in the value stream flow, therefore leading to the second-level analysis of the current state of the company.

The VSM developed for the company are represented in annexes I to M. In order to facilitate the understanding of the value chain, it was divided in two parts: the first comprising the processes between the customer request and the approval of the budget proposal, and the second representing the flow of activities ranging from the approval up to the installation of the commissioned project. The first one is referred to as "Negotiation Phase", and the second as "Operational Phase".

A VSM represents the flow of processes over time, by tracking the time it takes to perform each one in a timeline located at the bottom. The core business processes are modeled in rectangular boxes with information about its characteristics and operational performance parameters, which are listed as follows:

- Name of the process – how the core process was identified;
- Accountable role – which functional role is accountable for the performance of a process, as it is defined in the responsibility matrixes;
- Cycle time (CT) – the time span in which a unit flow is transformed in a process, which is value-added time;
- Lead time (LT) – the time span between the moment a unit flow enters a process and when it leaves, which may be equal or superior to CT;
- Ratio (CT/LT) – the percentage of time in which value added work is being performed on the unit flow.

It is possible to quantify the efficiency of an entire value chain, using the ratio of value added time (VAT) to total time (TT) of all processes. This percentage quantifies the amount of VAT versus non-value added time, which consists in the difference between TT and VAT.

The relationship between processes comes in the form of arrows, which represent two types of flow: information and material. This representation is determined by the kind of unit flow of the value chain. A unit flow consists in what is handed on from one process to another through successive transformations that culminate in the final offer to the customer. In this case, the unit flow considered for the elaboration of the VSM is the commissioned project. The work associated with project development has an administrative, office-like nature, therefore the unit flow is more informational rather than material.

In order to elaborate the VSM it was necessary to devise a work methodology that would define three aspects: the time horizon of data, the sources of collection of information, and the method of investigation.

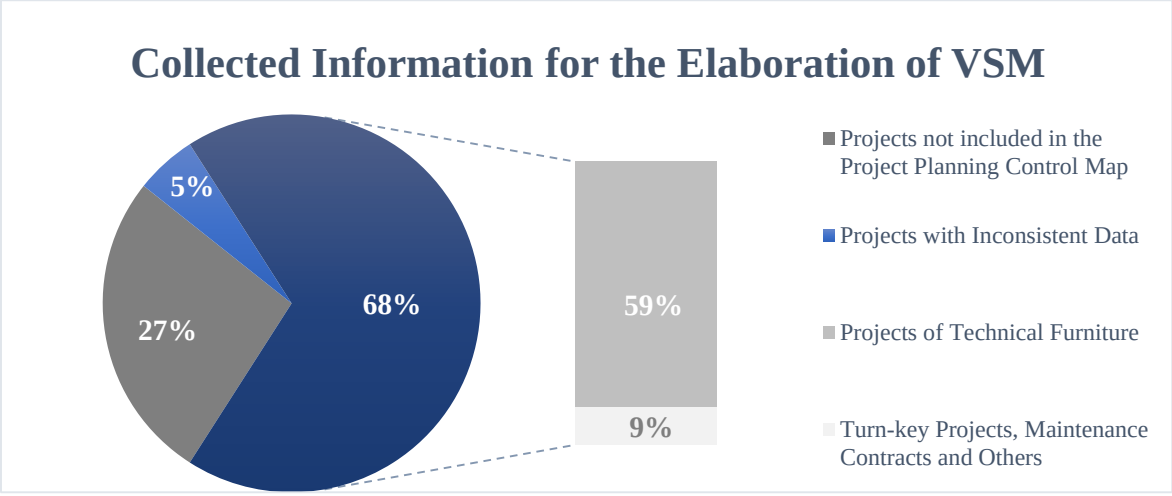
In the past few years, the structure of the company has undergone significant changes, therefore conditioning the operational performance of its processes. The last major change occurred in 2014 with the creation of a new functional role, the project technicians. Therefore, the collected data concerns the time between this moment of formation and the day when the data gathering process started, covering roughly eight months.

Three sources of information were used: quantitative data from the company's ERP software and the project planning control map filled in by project technicians, and qualitative aspects of work through questions asked directly to certain functional roles involved in the core processes. The goal was to obtain a significant sample of projects developed in the mentioned time horizon.

The company's ERP software indicates the existence of 571 projects developed between August 2014 and March 2015, whereas the project technicians' map reports 419 for the same time interval. This map provides detailed information about each project, such as the type of difficulties felt during its course. Therefore, it was chosen as the basis of analysis for the construction of the VSM, containing a 73% sample of all projects.

The method of investigation consisted in analyzing each project individually, tracking the time intervals between each core process of the value chain. Some of these time spans were taken directly from the project technicians' map, others had to be searched for in the ERP. Some of these projects presented inconsistent information about dates, having therefore been eliminated from the analysis. Consequently, the analysis is based upon a 68% sample of all projects. This sample consists in 87% of technical furniture related projects (59% of total), and 13% of turn-key projects and others (9% of total). As it was already mentioned, the focus of the analysis is the technical furniture business unit.

Graphic 4 demonstrates the dimension of the sample for analysis.



Graphic 4 – Collected Information for the Elaboration of VSM

A VSM reflects the value chain of one type of unit flow. In this case, there are four types of project that require different tasks in the phase "Planning of Project Execution" (Annex F), for which project technicians are responsible and accountable. As distinct activities imply differences in the complexity, CT and LT of a process, it was necessary to elaborate a VSM for each type of project. These four types were defined the following way:

- **Standard Project** – the customer request fits in the company's product portfolio;
- **Special Project without Prototypes** – the customer request involves customized solutions that are out of the company's portfolio, but that do not require the development of prototypes;
- **Special Project with Simple Prototypes** - the customer request involves customized solutions that are out of the company's portfolio, and that require the development of simple prototypes by project technicians;
- **Special Project with Complex Prototypes** – the customer request involves customized solutions that are out of the company's portfolio, and that require the development of complex prototypes with the collaboration between project technicians and developers.

Table 1 represents the frequency and LT of the four project types. About 24% of projects are strictly standard, and 76% have special features, which reflects the level of customization and flexibility that the company offers. The weighted average of the LT of the phase "Planning of Project Execution", taking into account all types of project, is of approximately 5 days.

Table 1 – VSM Parameters by Type of Project

Type of Project / Parameters	Standard	Special without Prototypes	Special with Simple Prototypes	Special with Complex Prototypes
LT (days)	1	3	6	27
Frequency (%)	24%	45%	23%	6%
Weighted Average (days)	4.6			

It was giving a special attention to this phase because it is the bottleneck of the value chain of the "Operational Phase". A bottleneck is a process, activity or resource that has the biggest LT of the entire value stream, therefore conditioning its operational performance. The obtained value for the ratio VAT to TT for the complete value chain was of 10%, using a weighted average that takes into account the different types of project.
In a VSM, the identification of waste in the value chain is done through the representation of «bursts». The following bursts were identified for the "Operational Phase":

- Projects take approximately 4 days between being approved and beginning to be worked on by project technicians – *waiting waste*;
- Projects spend about 5 days in the "Planning of Project Execution" phase – *waiting waste*;
- Stock picking and material separation by warehouse employees occurs too close to the dispatch time, sometimes just minutes before it happens – *waiting waste*;
- Extra dispatches are needed due to problems detected in the construction site, such as lack of materials/equipment, wrong materials/equipment, and damaged or defective materials/equipment – *defects* and *transportation waste*.

As for the "Negotiation Phase", the identified «burst» is related to the bottleneck - "Preparation of Proposal" - in which estimators are not able to keep up with the amount of budget requests made by project managers.

In subchapter 3.4, the root causes of the waste reported in these «bursts» are analyzed.

3.3 Organizational Design Analysis

It was necessary to investigate the evolution of the workforce and internal structure of the company over the years in order to understand the organizational structure that it adopts nowadays. In order to do so, two types of research were conducted: the consultation of the company's archive of documentation (manual of functional roles and annual management reports), and by questioning employees of different departments about their functions.

As it was mentioned in subchapter 3.1, the number of employees has been increasing over the years, having quadrupled in the last ten years. The grouping of employees into departments and the relationships of authority between them has accompanied the evolution of workforce and the increasing level of internationalization and diversification of the company.

Figure 5 represents the current interaction between the functional units of the company. It should be noted that it is not an organogram, but a graphic that demonstrates in a simple way how employees are distributed through hierarchic levels and how they interact with each other.

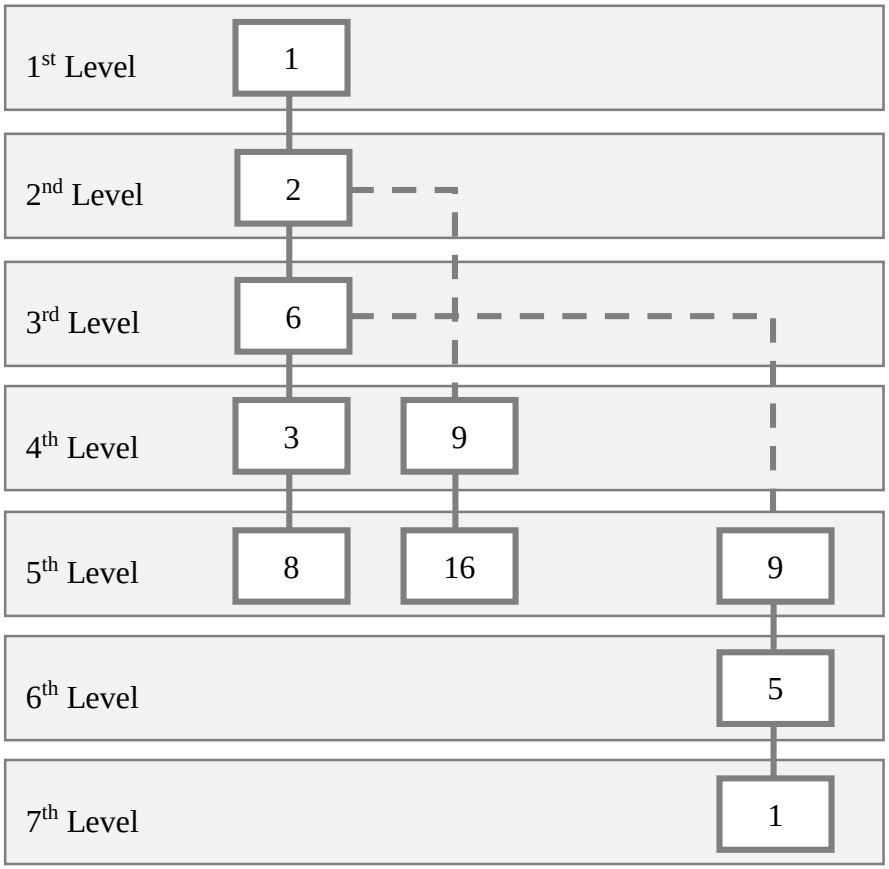


Figure 5 – Current Functional Dependencies

As of 2014, there were 86 people employed in the company, making up a total of 7 hierarchical levels, 60 functional units, and 15 departments. Figure 5 denotes two types of functional dependence: direct (solid lines) and indirect (dashed lines). Indirect dependence occurs when there is a relationship of dependence between two non-consecutive hierarchical levels. In this company, this kind of dependence exists between the second and the forth levels, and between the third and the fifth. The numbers in the boxes represent the number of functional units associated with the functional dependence in question.

By analyzing the diagram of Figure 5 and the company's organogram it was possible to observe the following facts:

- High level of horizontal differentiation – there are too many functional units (60) for the number of employees (86), which means that the there is a high level of specialization of work;
- High level of vertical differentiation – there are too many hierarchical levels (7) for the dimension of the company, and there should not exist indirect dependences between no-consecutive levels;
- Imbalance of span of control – the span of control in the company ranges from coordinating just one employee to managing 13 at the same time;
- Absence of functional logical – there is not a functional logic in the organogram (like a divisional or functional structure), and there is no distinction between staff (support functions) and line (core functions) units.

These characteristics generally have negative consequences for a company, many times in the form of surface and leadership waste:

- The existence of too many functional units and departments hinders communication between all the interfaces – *information waste*;
- The span of control of some employees is too wide, making it difficult to coordinate and control the work of subordinates, which should be no more than 9 (Lareau 2003, 56) – *structure waste*;
- The existence of indirect dependencies creates obstacles to the monitoring of subordinates – *leadership waste*;
- The fact that there is not a clear functional logic in the organogram may lead to employees' confusion about what is expected from them, and how their work contributes to the achievement of the company's goals – *focus waste*.

In subchapter 4.1, the topic of organizational design is further discussed in an improvement perspective.

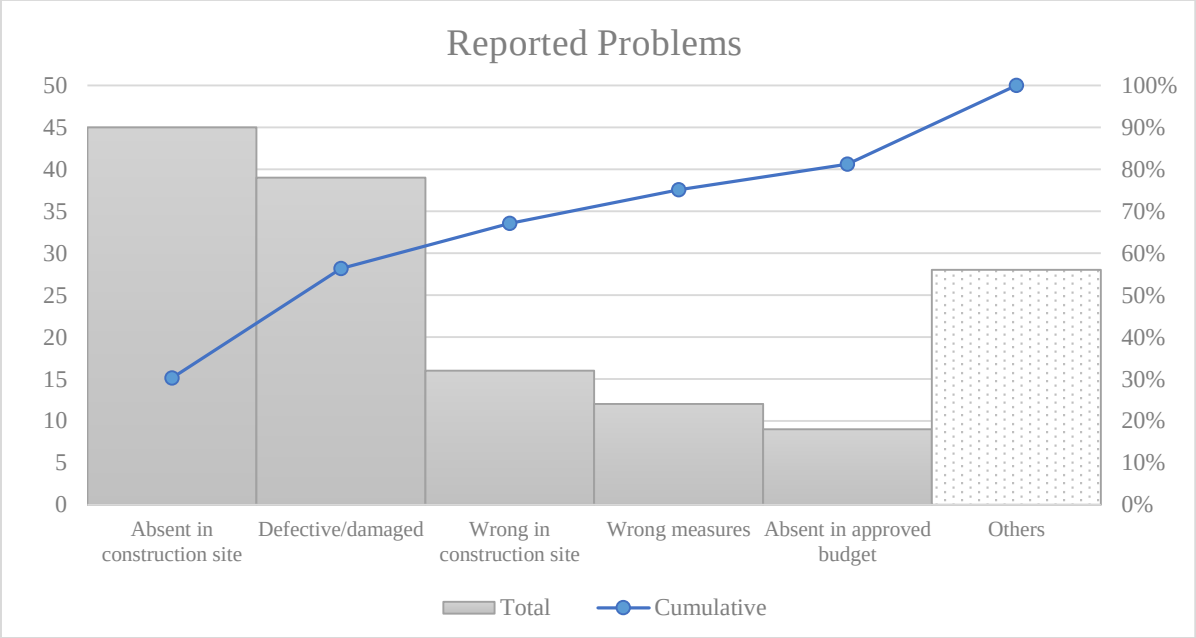
3.4 Root Causes of Problems

This final subchapter of the analysis of the current situation of the company exposes the root causes of the problems that it has been facing.

This analysis followed the method of investigation used in the second level analysis of the business processes. Therefore, data was collected from the same sources (ERP software and project technicians' map), covering the reported time horizon of roughly eight months. These two sources of information enable the consultation of a type of document that the company has been adopting as a part of its quality management system – the Problem Registry (PR). PR are filled in and stored in the ERP software. Three fundamental aspects of this problem solving mechanism were taken from the research: what type of problems were reported, at which phase of the value chain they were detected, and what causes were attributed to the occurrence of such problems.

Following Pareto's rule of 80/20, the goal of the research was to discover which few critical factors (usually around 20% of all that have been identified) contributed to the majority of occurrences (about 80% of them). By identifying and acting on these few causes, a great deal of the observed difficulties in the company will eventually disappear (Alfredson and Söderberg 2009, 14).

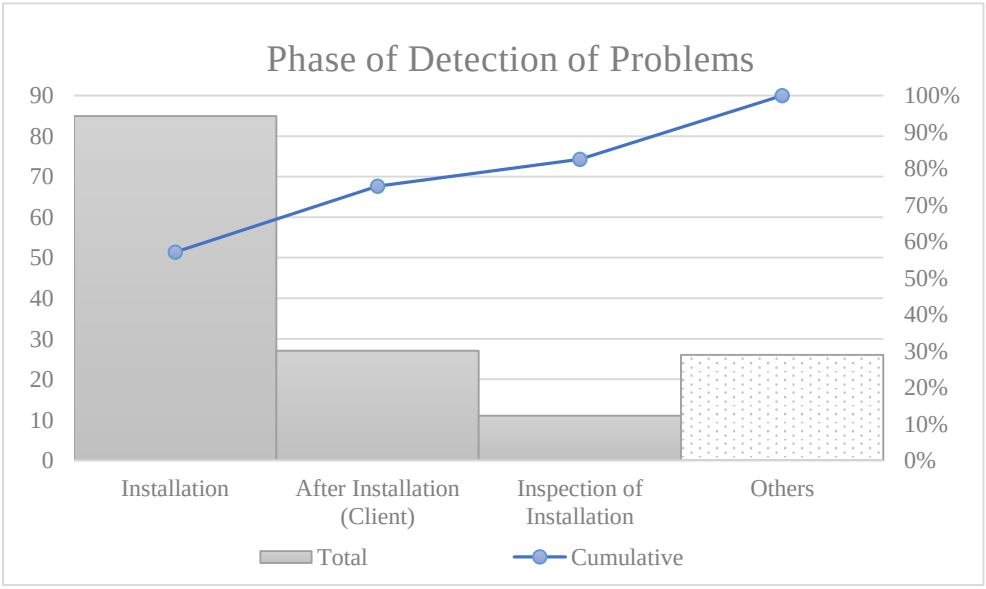
Graphic 5 is a Pareto chart of the reported problems.



Graphic 5 – Pareto Chart of the Reported Problems

The most common problems that were reported are relative to materials and equipment used in the installation of a project in a construction site. Usually, material and/or equipment is either absent in the construction site, and/or defective/damaged, therefore compromising the conclusion date of installation and requiring extra dispatches.

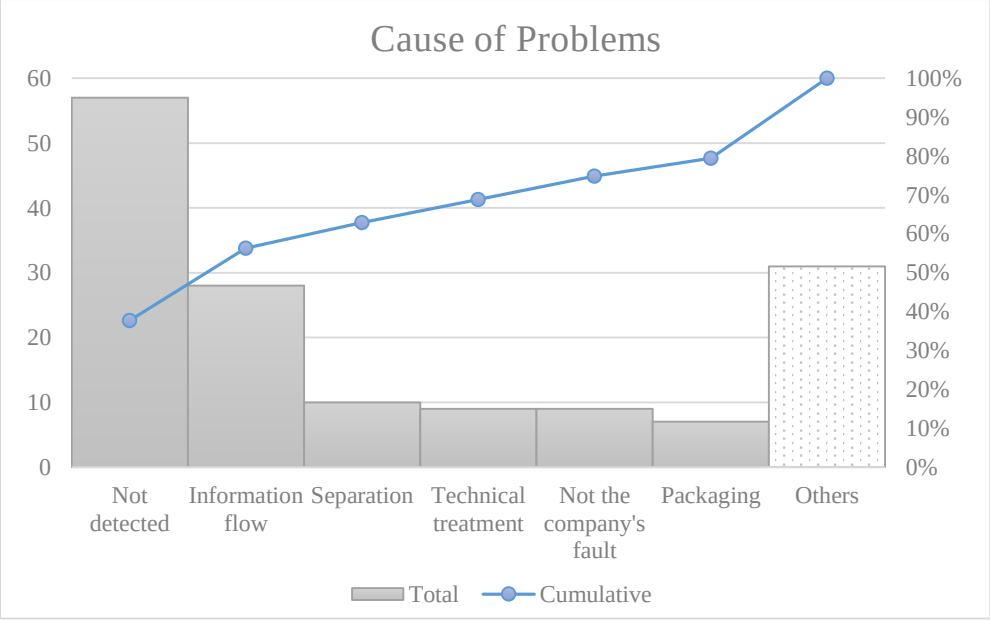
Graphic 6 demonstrates the most frequent phases of detection of the mentioned problems.



Graphic 6 – Pareto Chart of the Phases of Detection of Reported Problems

As it is evident from Graphic 6, the majority of problems are detected at the end of the value chain – the installation of the project, and the moments after that, in the form of client complaints.

Finally, the causes attributed to the occurrence of the problems are represented in Graphic 7.



Graphic 7 – Pareto Chart of the Causes of Reported Problems

A great portion of the analyzed PR do not provide a justification for the occurrence of the problems. In these cases, the absence of explanation comes in three scenarios:

- The PR is still in the phase of identification of the cause of the problem, therefore not complying with the defined period of five working days to do so;
- In the PR, the cause of occurrence is defined as «not detected»;
- The PR provides a vague and confusing explanation of what happened.

The most frequently identified cause of problems concerns the transmission of information between departments, highlighting the difficulty in communicating and tracking information that is felt by the company.

Other identified causes of occurrence are related to the wrong separation of materials/equipment before dispatch, flaws in the technical treatment by project technicians, unsafe packaging of materials/equipment for transportation, and mistakes made by external stakeholders, such as suppliers.

The analysis of the root causes of problems reflects the operational performance of the identified bottleneck (the phase "Planning of Project Execution"). The difficulties felt by employees involved in this process were apprehended by questioning them, and through the analysis of PR. The recurring constraints that are felt in this working phase are listed as follows:

- There is an absence of materials/equipment in the approved budget – *information waste*;
- The wrong materials/equipment are present in the approved budget – *information waste*;
- There are undefined details concerning the customer request, that many times are only decided by the customer and internally communicated by the project manager at a later stage of the technical treatment – *waiting waste* ;
- The customer request is not reflected in the approved budget due to poor communication between the project manager and the estimator – *information waste*;

- There is an excessive use of emails between project technicians and employees involved in the project (project manager, estimator, etc.) when communicating rectifications of a project, resulting in many important facts going unnoticed – *information waste*;
- The project technicians make mistakes inherent to their work, usually when dealing with special projects – *defects waste*;
- There are significant quantitative differences between virtual stock and physical stock, which difficult the management of net necessities – *information waste*;
- Many of the codes used in the codification of materials and equipment (both produced and purchased) are either outdated or not adequate to the company's current situation – *information waste*.

It was not possible to quantify the frequency of these types of constraints because such information is not reported in a structured problem-solving perspective. This topic is further analyzed in section 4.2, where improvement suggestions are made with the objective of developing a more systematic approach to the resolution of problems.

The current structure and procedure of the PR was analyzed, and the following facts were observed, either by direct observation or by questioning employees from different functional units:

- The designated time period of five working days to detect the cause of the problem and define corrective and/or preventive measures is usually exceeded;
- The problems are not properly typified into clusters according to the associated process of the value chain;
- The description of the problem is usually incomplete or confusing, because it consists in a transcription of the email that was sent by the person that reported it, instead of following a standard and clear procedure of explanation;
- The implementation and monitoring of preventive measures is practically inexistent;
- The PR mechanism is generally look upon as a mere bureaucratic action with little or no influence in the continuous improvement of the company.

The following ideas summarize the conducted analysis of the company's current situation:

- In the past few years, the company has undergone significant changes in its organizational structure and business, through an increasing specialization of work and level of internationalization;
- The company has not been able to adapt its structure and management system to these new realities, which led to the increment of operational errors;
- The root causes of the problems indicate a difficulty in communicating information between departments, an issue that stems from a poor visual management of work and a highly differentiated organizational structure;
- There is not a well-structured and effective method for solving problems and monitoring work performance.

These conclusions consist in a succinct diagnosis of the company's current condition, and serve as a starting point for the identification and analysis of improvement opportunities, a topic that is discussed in chapter 4.

4 Identification and Analysis of Improvement Opportunities

The diagnosis that was presented at the end of the previous chapter consisted in the starting point for the formulation of the improvement suggestions that are identified and analyzed in this chapter.

These improvement suggestions for the company are characterized in distinct sections, according to four dimensions: organizational structure, visual management, quality management system, and some additional considerations regarding the company's portfolio of products and its technological support. Each of these subchapters provides a detailed description of the improvement opportunity, and explains how its implementation may be beneficial for the company. This set of suggestions form the «to-be» model for the company.

The chapter is concluded with a brief cost-benefit analysis of the execution of the referred ideas, in the form of a decision-making tool - a matrix table - that the company may use in the near future.

4.1 Organizational Design

This subchapter addresses the difficulties that were identified in the section 3.3, relative to the current organizational structure. The suggested ideas refer to two topics: the organogram of the company, and the organization of its physical and administrative resources.

4.1.1 A More Adequate Organizational Structure

Concerning the company's organizational structure, four different scenarios were developed and compared to each other. They consist in the following organizational structures: functional, divisional, matrix, and multidivisional.

Annex N depicts the suggested functional structure for the company. Functional units are organized in three hierarchical levels, the first consisting in the Administration, the second comprising the managers of both staff departments (Quality, Human Resources, Finances, and Accounting) and line managers (Sourcing, Commercial, Product Development, and Operations), and the third involving employees that are subordinated to staff and line managers.

A functional structure is one in which employees and resources are organized in a way that prioritizes its core functions. These consist in the following: sourcing of suppliers, market-related functions (selling, budgeting, and marketing), product development (which is divided in the three business units of the company), and operations (the set of tasks that are performed once the budget has been approved by the customer).

This structure provides a better allocation of resources than the current one by reducing both vertical and horizontal differentiation, through the establishment of direct dependences between functional units, and by decreasing the span of control wherever it had been characterized as excessive in subchapter 3.3 - the maximum span of control in this case is of 8 employees. However, this structure potentially aggravates the problems of the current organogram, concerning the difficulty in communicating and transmitting information between departments, which is due to a highly specialized division of labor. A functional structure not only increases functional barriers, but is also inadequate to a company operating in more than one business unit, because different businesses require distinct support functions.

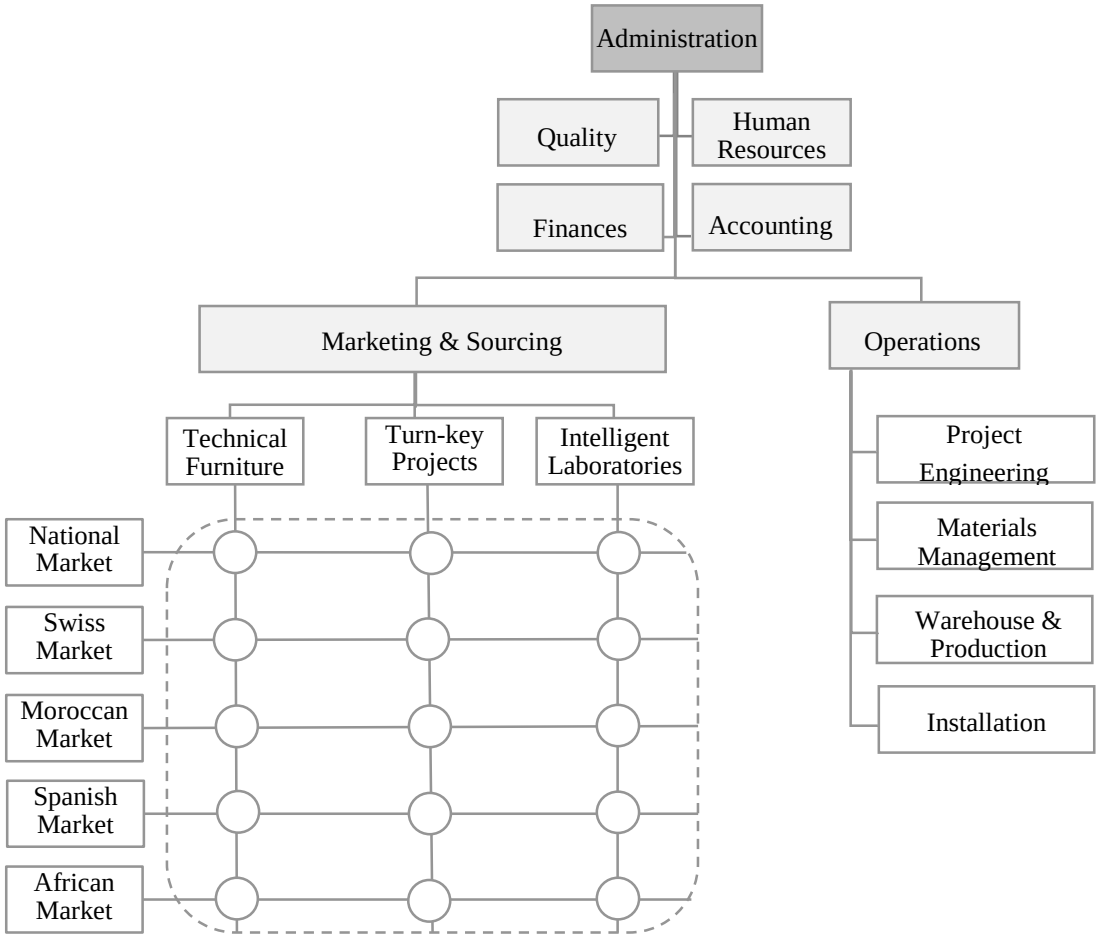
Annex O represents a suggested divisional structure for the company. The sourcing and operations departments of the functional structure are maintained, because these functions are

common to the three business units of the company. The other departments consist in three divisions, one for each business unit – Technical Furniture, Turn-key Projects, and Intelligent Laboratories. A division contains four teams of employees, each one dedicated to a support function: product development, sales, budgeting, and marketing.

A divisional structure is more adequate to a company operating in more than one business unit, because employees are distributed into work groups dedicated to a business unit, therefore developing skills that make them more able to successfully deal with specific requirements of a business. As support functions are divided by business areas, it is necessary to assure cohesion across the company, in order to prevent the formation of functional silos, i.e., departments/teams of employees that fail at communicating with each other. An integrating mechanism (as the ones mentioned in subchapter 2.4) is absent in this model, which may compromise the sharing of knowledge between different divisions which, in turn, could lead to employees feeling like they are working in distinct companies, rather than in different divisions. The span of control of this structure has a maximum value of 9 employees.

Annex P depicts a matrix view of the organization, in which staff departments are maintained (just as in the previous models), and both core functions and business divisions are taken into account. They form the vertical and horizontal dimensions of the matrix, respectively. The line managers are the directors of each core function and business unit division. The intersection of a core function and a division consists in a functional unit, in which employees are subordinated to the two corresponding line managers. Therefore, a project/task that is undertaken in a business division goes through all the core functions in order to be completed. During its course, it is necessary to coordinate work between the divisional manager and the successive functional managers. Despite promoting a high flexibility and rotation of employees, this situation is likely to originate conflicts of interest between the many interfaces, which alongside the absence of an integrating mechanism of the different functional units may cause instability in the company. The span of control reaches the number of 11 employees, which surpasses the recommended maximum of 9 workers, as it was mentioned in subchapter 3.3.

Finally, Figure 6 represents a multidivisional structure of the company, which tries to solve the difficulties that the other models could not overcome. This structure introduces the use of an integrating mechanism, which is very important for this type of company due to the high variability of products and markets that it has to deal with. This new role implies the creation of a hierarchical level, the corporate management one, which was mentioned in subsection 2.4. Just as there is an Operations director that supervises and controls the work of all operational departments, there is a director of Market whose responsibility consists in coordinating activities and knowledge-sharing between the different business units and markets in which the company operates. This functional unit combines information from a variety of sources and uses it to develop marketing and sourcing plans. The maximum span of control in this structure is of 6 employees.



(Project Manager, Estimator)

Figure 6 – Suggestion: Multidivisional Structure

The five main markets that the company serves are the national one, the Swiss, the Spanish, the African, and the Moroccan (which is set apart from the African one due to the Morocco subsidiary being wholly owned by the company, contrary to other African subsidiaries). Unlike the previous suggestions and the current organogram, this one represents the subsidiaries and indicates how they are coordinated from the headquarters. There are market and division directors (which are located in the headquarters or abroad), who following the matrix logic of the previous structure coordinate the project manager and estimator assigned to a project in a specific market and business unit. The business divisions consist in development teams, and market divisions are represented by a project manager who coordinates the other project

managers of that market. The marketing and sourcing functions are centralized at the corporate management level.

This multidivisional structure has the same advantages and disadvantages of the matrix structure, because it adopts this configuration for the market division. However, it possesses the advantage of integrating knowledge of the different market segments which, in a way, promotes coordination between the interfaces of the matrix. On the other hand, the creation of a new hierarchical level may lead to conflicts in the relationships between corporate managers and line managers.
Table 2 synthesizes the advantages and disadvantages of each suggested structure for the organization. The multidivisional structure is considered to be the most adequate for the company.

Table 2 – Advantages and Disadvantages of Different Organizational Structures

Structure	Advantage(s)	Disadvantage(s)
Functional	• Development of skills related to a specific core function of the business.	• Not able to meet specific requirements of a business unit and/or of a market; • Absence of an integrating mechanism of the different business units.
Divisional	• Development of skills related to a specific business unit.	• Absence of an integrating mechanism of the different business units.
Matrix	• High flexibility and rotation of employees; • Cross-functional approach to work.	• Possibility of conflict between the business unit manager and the core function manager; • Absence of an integrating mechanism of the different business units.
Multidivisional	• Integrating mechanism of the different business units and markets (corporate management); • High flexibility and rotation of employees; • Cross-functional approach to work.	• Possibility of conflict between the business unit manager and the market manager.

4.1.2 A More Visual Office Layout

According to Lindlöf *et al* (2013), a typical problem of product development companies concerns the management of information, as this type of organizations has knowledge-intensive work. An effective method for overcoming such difficulties relies in the implementation of a visual management system, consisting in an "(…) approach in which the condition and status

of every relevant element of a work environment (…) is openly displayed and updated so that everyone knows what to do and when to do it" (Lareau 2003, 170). Therefore, the implementation and maintenance of a visual working place "(…) aims to deal with the large amount of information often available in an R&D organization" (Lindlöf *et al*, 2013).

Figure 7 reinforces the idea that an excessive amount of information is an obstacle to the successful performance of a company. While a reasonable amount of information is necessary for the functioning of an organization, once a critical point is exceeded, the overload of information becomes a burden for employees, who become confused about what they are doing and lose the notion of how their work impacts the rest of the company.

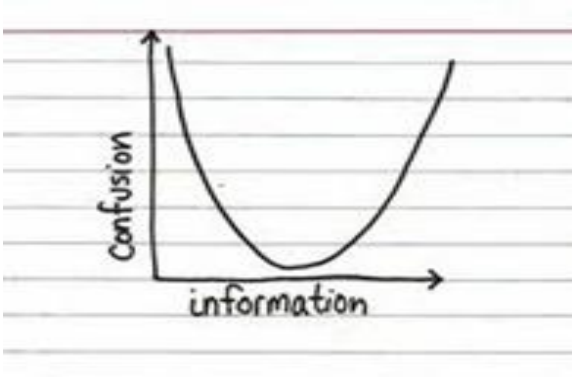


Figure 7 – Amount of Information versus Confusion (Kaizen Institute, 2015)

The company that is analyzed has a significant R&D component, reflected in the existence of three distinct business units (technical furniture, turn-key projects and intelligent laboratories), each demanding a very specialized knowledge and working activities, which translates into a great variety of information and an excessive horizontal differentiation in its current organogram. The combination of these business characteristics and the difficulties in transmitting information and identifying the root causes of problems (explained in subchapter 3.4) evidence the necessity of a visual management system, which is currently not adopted by the company.

Therefore, the suggestion that is presented in this section consists in the redesign of the office layout in a way that increases awareness of what is happening in every working group and department, and of how the performance of each one affects the quality of the output delivered by the organization. The suggested visual management system is focused on the offices of the company due to it being more oriented to services than to manufacturing. However, a visual system for the company's warehouse and production facilities is strongly recommended as a work to be developed in the near future, which is mentioned in chapter 5.

The new office layout consists in rearranging the physical allocation of employees/departments, and in creating an *Obeya* Room, which in Japanese means «big/large room», and that is also referred to as War Room. According to Kaizen Institute (2015), an *Obeya* Room is based on the idea that if a company sets up a physical space dedicated to coordinating employees and solving problems, its functional barriers will become weaker over time. This physical space may be inserted in an existing working place, or in a separate room that is created specifically for it. In this place, visual data about the state of a project/work developed in the company is displayed in a way that everyone understands, making it a gathering point for employees to briefly discuss the progress of work on a daily basis (Lindlöf *et al*, 2013).

There are mainly three types of waste that are addressed in the proposed visual system – *people*, *information* and *leadership* waste. The means through which these forms of waste are reduced are explained as follows:

- *People* waste – this type of surface waste is diminished because the departments that need to work together in the course of a process are located next to each other, thereby reducing waiting and motion of employees;
- *Information* waste – this form of surface waste is reduced due to the visual display of relevant information about the progress of a certain task/project and the working plans for working groups both in the short and long term;
- *Leadership* waste – this waste is addressed through the implementation of daily gatherings at the *Obeya* Room, a practice that is part of a Lean Daily Management System (LDMS) (Lareau, 2003).

Annex Q represents the current office layout of the company, and Annex R depicts the proposed layout. The absence of a logical distribution of employees is evident in Annex Q, where departments were classified in four functional areas through a color scheme: Staff, Operations, Market-Negotiation, and Market-R&D. Construction supervisors are located on the second floor, whilst the other operational departments are placed next to each other on the first floor, close to the dispatch zone. Moreover, the key functional units involved in the negotiation with the client – project managers and estimators – are located on different floors as well. Taking into account the high level of interaction between project managers, estimators, and project technicians, it is recommended that these employees are placed next to each other, on the same floor. This suggestion is represented in Annex R, where it is possible to observe that the same functional areas are located next to each other.

Annex R also indicates the location of the *Obeya* Room. The chosen place is the division where project technicians, purchasers, construction supervisors, and the chief of operations work. It is considered to be the most suitable room because it is where most operational work takes place, and it is physically nearer to the functional units that are involved in the operational phase alongside Project Engineering, Purchasing, and Installation, which are project managers, estimators, and employees belonging to the Warehouse and Production functional units.

The layout of the *Obeya* Room is depicted in Annex S. Kaizen Institute (2015) asserts that the *Obeya* Room is a powerful instrument for the implementation of the Plan, Do, Check, and Act (PDCA) cycle in the daily work of a company. The PDCA cycle, created by American quality-guru W. Edwards Deming, consists in a four-step quality mechanism that aims to eliminate problems in a systematic and continuous way. These four phases are reflect in the typical layout of an *Obeya* Room.

The first one (Plan) involves the formulation of a plan of the work executed by a functional unit/department, and the definition of department/personal goals and of how these objectives are aligned with the goals of the company. Annexes T, U, and V contain templates that were developed for the visualization of the Plan phase in the *Obeya* Room. Annex T contains a macro-plan poster in which projects are represented in a timeline, Annex U depicts the template of a micro plan poster of weekly work of a working group, and Annex V represents the suggested poster for tracking the progress of a specific project.

The second step (Do) consists in the execution of was planned in the previous phase, which is reflected in the evaluation of the performance of a process and/or department. The definition of Key Performance Indicators (KPI) used in the assessment of work is done in section 4.2.2.

The third phase (Check) comprises both the monitoring of work and the detection and reporting of problems that occur daily. Finally, the fourth step (Act) involves acting on the problems that are identified and assuring that quality policies are standardized and maintained over time, so that they become a part of the company's culture. This phase is further explained in section 4.2.1.

The *Obeya* Room can only be effective if the LDMS is understood and accepted by employees, and thereby performed in the daily routine of the company. Lareau (2003) defends that the primary goal of LDMS is "(…) to provide focus, structure, discipline, and ownership within each discrete, intact work group in the organization". Therefore, the implementation of LDMS is a powerful tool used to reduce leadership waste, while at the same time increasing employee's perception of how work is being conducted not only in their department, but also in the rest of the company.

The LDMS implies the occurrence of daily group meetings, in which an intact work group's members (employees performing related tasks near each other) get together in front of the *Obeya* posters, standing up instead of sitting. These meetings are conducted by a work group leader and should not take longer than fifteen minutes, during which the main events of the previous day are mentioned, the quality problems of the day are reported, daily tasks are assigned, and data is registered in posters for later performance analysis. While these aspects are debated on a daily basis, others are discussed less frequently, such as the status of a long-term improvement plan and the analysis of the department, work group, and/or process performance (Lareau, 2003).

4.2 Quality Management System

This chapter contains the suggestions related to the restructuring of the quality management system that is currently adopted by the company. The first section focuses on the formulation of a new method for solving problems, and the second one presents the foundations of the proposed quality system, which is based upon the concept of process management.

4.2.1 A More Effective Problem Solving Method

The *Obeya* Room's walls are covered with graphical data that is displayed in a clear, simple, and intuitive way, usually in the form of A3 reports. This visual tool is used by Toyota as a means of stimulating the intellectual development of its employees and enabling a quick and effective method for solving problems (Sobek and Smalley 2008). Therefore, A3 posters imply not only the adoption of a new habit in the workplace, but also, and most importantly, a change in the mindset of employees and managers, which is designated as "A3 Thinking" by authors Art Smalley and Durward K. Sobek, who wrote the book "Understanding A3 Thinking: A Critical Component of Toyota's PDCA Management System" in 2008 (Sobek and Smalley 2008).

The management philosophy behind the concept of "A3 Thinking" is based upon three pillars: problem solving, mentoring and communication/collaboration (A3 Thinking Blog 2011). The typical A3 problem solving poster typically contains seven sections that, in a succinct way, explain the whole process that is associated with problem solving through the use of graphics and other visual tools:

- Background – the context that precedes the problem;
- Current State – the current state that reveals the existence of a problem;
- Goal – the target state that aims to be achieved once the problem is removed;

- Analysis – the identification of the root causes of the problem;
- Countermeasures – an action plan of measures to be implemented in order to solve the problem, with the definition of the Five «Ws» (5W) – *what* the measure consists in, *who* executes it, *when* it has to be completed, *where* it has to be performed, and *why* it has to be implemented;
- Check Results – the comparison between the target state and the situation that is achieved through the implementation of the measures;
- Follow-up – the establishment of standard procedures and the dissemination of lessons that were learned from the problem solving process (A3 Thinking Blog 2011).

The second pillar of "A3 Thinking" – mentoring – reflects the learning mechanism in which the leader of an intact work group provides feedback about its performance over time and develops the culture of continuous improvement. Finally, "A3 Thinking" increases communication and collaboration because it implies the involvement of all employees and replaces long reunions with short and focused stand-up meetings.

The implementation of a new problem solving method implies that PR have to be restructured in order to be aligned with the visual management system that is to be implemented, thereby improving its standard procedures and characteristics, which were analyzed in subchapter 3.4.

The current PR system has two main flaws. It is further explained how the new problem solving mechanism addresses each of them:

- Absence of clustering – the new problem solving mechanism classifies problems according to the type of process it refers to (core, management or support process), therefore allowing a clearer notion of the performance of each process, and enabling the definition of more adequate follow-up mechanisms for each of them;
- Lack of structured mechanisms of analysis and follow-up– the problem solving system that is to be implemented defines a simple, quick and effective way of detecting the root causes of a problem (through the use of a cause-effect diagram), and establishes the procedures that have to be put into practice in order to remove the problem (consisting in the 5W method).

The template that was developed for the A3 problem solving report is represented in Annex W. Out of the seven dimensions of the poster, the one entitled "Root Cause Analysis" is especially relevant because it introduces a new quality tool – the Cause-Effect Diagram, also known as Fishbone Diagram or Ishikawa Diagram. According to ASQ (2014), this type of graphic is used when trying to identify the likely causes for the occurrence of an observed problem, through a brainstorming-like session in which employees are encouraged to collaborate in the detection of the root cause. Generally, the categories of suspected causes comprise six dimensions: failures deriving from machines/equipment, materials, measurement procedures, working methods, people, and the surrounding environment. Likely causes of the problem are listed for each category, and sub-causes (derivations of causes) are mentioned whenever applicable. The follow-up mechanism involves assigning an action plan for each possible cause, in the form of a 5W table with the inclusion of a field for indicating the status of the investigation of each probable cause. The 5W parameters included in the table are *what*, *who*, and *when*.

Concerning the practicability of a visual management system in a project-based company, it was conducted a research with the goal of finding a dissertation in which an empirical study regarding the implementation of such a system would be included. A dissertation written by two master degree students of Product Development at Chalmers University of Technology (Göteborg, Sweden) was consulted and relevant aspects of the referred topic were analyzed.

The thesis was developed within a project that resulted from the collaboration between the authors and Swerea, a Swedish research institute. Five Swedish companies were interviewed with the objective of understanding to what extent knowledge is visually transmitted in project-based companies of that country.

One of the difficulties that were reported by these companies consisted in having the necessary focus to maintain the visual management system due to the pressure of keeping up with project deadlines (Alfredson and Söderberg 2009, 55). Another obstacle to the sharing of knowledge between projects and functional units resulted from both the external and internal turnover of employees who had made important contributions to the evolution of knowledge in a company (Alfredson and Söderberg 2009, 56). Therefore, it is recommended that new employees are given a thorough initial training, and that knowledge is shared in a continuous way in order to prevent its loss once key workers leave the company.

The proposed problem solving method consists in a continuous improvement mechanism, comprising both the A3 report and the restructured PR. The suggested model requires an analysis of a PR in order to determine whether there is an improvement opportunity that eventually leads to the formulation of a medium to long term project, which is represented in an A3 report. On the other hand, if a PR reports the occurrence of a problem that is currently being analyzed in an A3 poster, it serves as an input for the quantitative characterization of the current state of the problem. This distinction between short term and long term problem solving perspectives is also mentioned by Alfredson and Söderberg (2009, 57-58), who state that different problem solving approaches are applied in one of the studied companies. Firstly, a quick fix to the reported problem is performed so as to allow the continuity of work, a tactic that corresponds to the restructured PR. It is followed by the analysis of the root source of the problem so that future errors can be prevented, a method that is put into practice by the use of A3 reports.

Every Swedish company that was analyzed had been adopting some kind of visual mechanism in at least one of their departments, and one of them even managed to eliminate the need for project reunions, only performing meetings in front of the visual board (Alfredson and Söderberg 2009, 65). It was pointed out by these companies, however, that managers have to devise a mechanism for storing the A3 reports so that knowledge about how work should be and should not be done is accessible to both current and future employees.

4.2.2 A New Approach to Process Management

The proposed quality management system is process-oriented rather than focused on departments, so that employees are more aware of how their performance influences the output of the entire value chain. Therefore, it is necessary to create KPI for each process of the value chain of the company. The performance of a process may require the effort of more than one department and/or functional unit, which stimulates cooperation between employees. These KPI are visually represented and updated in the Check section of the *Obeya* Room.

According to Kaizen Institute (2015), in order to measure the performance in a lean environment, it is necessary to develop a structured monitoring system that covers three dimensions: the definition of what to measure, its frequency of evaluation, and the method used for controlling it. Concerning the first aspect, the formulation of KPI has to take into account that both outputs and processes have to be measured, in a cause-effect logic. This means that it is not sufficient to monitor the output of a process, because it does not provide a notion about which critical factors are conditioning its results. The second dimension establishes the

frequency of measurement, and the third reflects the mechanisms used for assuring that performance monitoring is maintained over time.

The definition of what to measure is only possible once processes have been restructured according to the BPR philosophy. Annexes AA, AB, and AC contain the new responsibility matrixes. The process "Dispatch and Install Project" was not reengineered.

The proposed changes for the core processes and functional roles are described as follows:

- ***Kanban* Systems** – These mechanisms require the definition of a maximum number of budgets/projects that are simultaneously processed by estimators/project technicians (respectively), so as to avoid work overload and increase employee's concentration, therefore preventing the occurrence of errors.

  The «as-is» VSM represented in annexes I to M highlight the work overload of estimators and project technicians. In a week, 30 budget requests are made by project managers, but only 12 out of those 30 are delivered by the end of the week (about 40% of the total) by the team of 7 estimators. Therefore, it is recommended that at least one of the following measures is put into practice, to avoid the future occurrence of a performance bottleneck:

  - Restricting the number of budget requests by project managers;
  - Increasing the number of estimators (30 budget requests require 18 estimators);
  - Separating estimators according to different types of budget and/or market.

  In a similar way, project technicians cannot keep up with the amount of project initiation requests that arrive every day. While standard projects requests are answered within a week, the other types are not. There are currently 4 project technicians, who either work individually in standard projects, or in pairs in special projects (consisting in a technician responsible for the specification of measures and the one specialized in the elaboration of technical drawings). The comparison between this functional unit's capacity and the internal demand it faces enables the detection of improvement opportunities. In fact, out of the 15 project initiation requests that arrive every week, only 8 of them are completed by the end of it (four standard, three special without prototypes, and one special with simple prototypes). Taking into account that at this point of the value chain employees feel pressured to comply with deadlines, and that each kind of project requires different activities and distinct levels of operational effort, the following suggestions are made:

  - Restricting the amount of project initiation requests that are worked on simultaneously by project technicians;
  - Increasing the number of project technicians;
  - Separating this functional unit according to the type of projects (standard, simple special and complex special), building a distinct model cell for each one, and therefore developing specific skills that meet the requirements of each type.
- **Materials Management Team** – Whereas the employee responsible for the management of net necessities is currently working in the same functional unit as project technicians, it is proposed that the mentioned employee integrates the same team as purchasers, with the aim of increasing communication between these two functional units and, therefore, reinforce this critical area of the company's business.
- **Internal Project Manager** – This proposed functional role is not fixed, i.e., it is designated for each project an internal project manager by the Chief of Operations, and

this worker can be either the commercial manager of the project, the project technician, or a member of the materials management team. This employee has the responsibility of tracking the progress of a project in the Project Status Poster (Annex V), of controlling the work of suppliers, warehouse workers, and production employees, and in that way increase the perception of the flow of information associated with the project. In order to avoid confusion, project managers (the current designation adopted by the company) are referred as commercial managers from this point of the dissertation.

- **Budget Validation** – Project technicians often detect budgeting errors such as lack of material, absence of material, or inconsistencies between what is reported by the commercial manager as the will of the customer and what is, in fact, reflected in the approved budget. Instead of requesting rework from estimators and delegating the task of rectifying the approved budget to the construction supervisor, it is recommended that the director of the estimators' department takes the responsibility of approving a final version of the budget with the corresponding commercial manager. This change aims to increase this director's experience and technical know-how, prevent the loss of knowledge when the construction supervisor (who has a considerate working experience) leaves the company, avoid the occurrence of mistakes and incoherencies, and create a more linear flow in the Activity 2 highlighted in the «as-is» responsibility matrix represented in Annex F. In the proposed responsibility matrix of Annex AB, estimators are no longer consulted during the course of the technical treatment. In case of doubt about the customer's request, the commercial manager is contacted.
- ***Obeya* Room** – Instead of controlling work through weekly reunions that last many hours (a current reality in this company), daily meetings that take no more than fifteen minutes are held at the *Obeya* Room, using the visual tools depicted in annexes T, U, and V. This new approach replaces Activity 3 mentioned in the «as-is» responsibility matrix of Annex G, for which no employee was accountable, which in turn led to the absence of control of the state of all projects.

Once the «to-be» processes have been described, it is possible to define what should be measured, who is to be responsible for the monitoring, and how it will be done.

Annex AD contains a list of the suggested KPI for the work group level, i.e., a set of metrics that aim to evaluate the operational performance of the core processes.

According to Lareau (2003, 135), the "(...) correct approach is to implement metrics within the work area that allow appropriate action to be taken by the intact work group without management being aware of the problem". This means that it is necessary to separate the evaluation of operational performance from the assessment of management practices, because operational work can only be measured by employees who can directly influence its output.

Annex AD classifies KPI according to its nature (cause or effect) and the frequency with which they should be measured. A KPI categorized as «cause» addresses the critical factors that contribute to the success of a process, whereas the ones labeled as «effect» measure its output. Therefore, a «cause» KPI enables a better understanding of what is conditioning performance, and consequently a quicker response whenever a problem occurs. These type of KPI tend to be evaluated more frequently than the «effect» ones (daily or weekly), for the mentioned reason of providing an anticipated view of what a process will deliver.

In Annex AD, the KPI marked with an asterisk should be given a special attention. They refer to the percentage of budgets, projects or materials management processes that were rectified, i.e., that were reworked. As these KPI are measuring the result of a process, it is important to

understand what caused such rework, so that preventive measures that address each factor can be implemented.

The rectification of budgets may have been caused by the following factors:

- Distraction of the estimator;
- Lack of knowledge of the estimator;
- Ineffective communication between the commercial manager and the estimator;
- Ineffective communication between the commercial manager and the client.

The rectification of technical treatments may be due to the same factors, in this case referring to project technicians instead of estimators, and to the communication between project technicians and commercial agents or developers. An analogous thinking can be applied to the materials management team.

On the other hand, the problems detected in the construction site may be categorized the following way:

- Lack of material/equipment;
- Wrong material/equipment;
- Material/equipment that has the wrong measures;
- Damaged material/equipment;
- Defective material/equipment;
- Defective assembly and/or installation of material.

Adequate "(…) management metrics (…) assess how well management implements, coaches, and maintains such a system." (Lareau 2003, 135). There were considered three levels of management:

- **Change Committee** – A cross-functional team responsible for monitoring the progress of the various change projects, for the definition of goals and priorities, and for attending monthly reunions.
- **Work Group Champion** – A member of the change committee responsible for mentoring and giving support to one or more work groups, and for attending a brief weekly reunion with the work group leader. A similar concept is applied by the Swedish company Scania (Alfred and Söderberg 2009, 68-69), in which a sense of ownership by the work group members is encouraged.
- **Work Group Leader** – The designated member of the work group that has the responsibility of coordinating the daily reunions.

These management roles are based on the ones proposed by Lareau (2003).

Annex AE represents the KPI that were formulated for the management level, which aim to evaluate whether managers promote focus and discipline across all members of the company that are actively contributing to the change projects that are currently being implemented.

4.3 Other Considerations

In this subchapter, additional considerations regarding improvement opportunities are presented. The analysis of the company was focused on the administrative processes and the quality management system, therefore the main suggestions are related to these aspects. However, these supplementary ideas should be mentioned as future work recommendations. They are related to two topics: the control of demand and stocks, and the technological support systems.

4.3.1 A Better Control of Demand and Stocks

The increasing level of customization and variability of the company's offer is reflected in the percentage of references of special products that were used in projects. A special product is one that is not standard, that has specific characteristics that the customer has requested, such as dimensions, colors, and materials that differ from what is defined by the company or the suppliers in its product lines. Ever since the moment when the company started to control its stocks rotation through the ERP software, about 39% of product references are related to customized solutions (a value that was obtained through an analysis performed on the ERP system).

This increasing complexity of product references and the growing level of internationalization that the company has experienced in the past few years have generated entropy within its internal processes, a fact that is reflected in the operational bottleneck of the process performed by project technicians, and in the types of difficulties reported by these employees that concern the great discrepancies between physical and virtual stock.

Moreover, some of the *gemba* walks performed as a method for investigation and the informal interviews conducted with some of the employees revealed a major difficulty that is usually not reported in the PR. Both warehouse and production employees are not able to perform their work at the required pace because of the existence of many errors related to the incorrect creation of product references, the fact that some of them are outdated, the absence of production drawings and/or technical details that are necessary for a correct production, and the disorganization of the physical space of the warehouse. Therefore, the following improvement measures are suggested:

- **Restructuring of the codification system** - The references that have errors need to be corrected, and the current codification system may have to be redesigned in order to reduce variability.
- **Supervision of suppliers** – This suggestion was explained in section 4.2.2.
- ***Kanban* systems in the warehouse facilities** – in order to reduce some of the stock inconsistencies and to simplify its control, *Kanban* systems could be implemented in some warehouse sections (such as the one dedicated to the storage of product samples).
- **Implementation of visual management in the warehouse facilities** – The weekly plan poster described in section 4.1.2 should be applied to the warehouse. Other visual management practices should be taken into account, such as the physical separation of raw materials and finished products (and the designation of respective accountable employees), and the widening of the space that is reserved for the reception of materials from suppliers.
- **Characterization of the product portfolio** – In order to control the variability of demand, it would be useful for the company to create a sorting mechanism that would operate whenever a new customer request would take place. This sorting mechanism would decide whether it would be strategic for the company to work on such a project. It could be based on the grouping of products in ranges, and on the definition of which customer segments would be served by each product range.

  Figure 8 demonstrates the trade-off between product variability and production volume. An increasing customization requires significantly more costs in activities like production, drawing and projection of technical details, and negotiation with the customer. Therefore, a company can only benefit from customization if it is applied to specific and strategic market segments, thus conditioning the volume of production.

With a level of customization of 39%, the company has positioned itself in a point in Figure 8 where both variability and volume are high, a situation that can be described as «mass customization». In order to be more cost-effective, it is recommended that it decreases its quantity of special products in the case it wants to maintain its production volume.

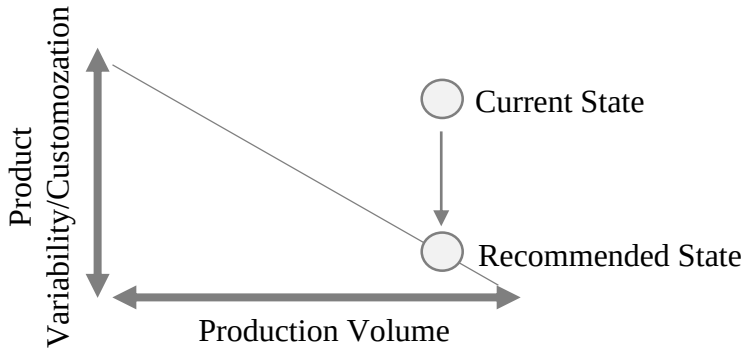


Figure 8 – Trade-off between Variability and Volume

4.3.2 A More Adequate Approach to the Technological Support

The performed *gemba* walks and the interviews conducted with some employees of the company have revealed its great dependence on the ERP software it has chosen at the beginning of its activity. In fact, the company has been customizing its ERP to such an extent that customization requests from employees have become a part of its culture. Over the past years, the modifications of the ERP software were done without the careful supervision and long-term vision that such changes require, having been implemented as quick fixes to urgent problems that surfaced. This has led to an increasing computerization and customization of processes, a reality that, in turn, has reduced the employees' understanding of how information is processed, and has increased the dependence on the Informatics functional unit to explain how procedures were computerized whenever doubts would arise.

Some suggestions are made regarding a more stable and adequate approach to the use of technological support systems in this company:

- **Purchasing of a separate Material Requirement Planning (MRP) module** – The company has been customizing its ERP system in order to create from scratch an internal MRP module. The ERP that was adopted is a common choice for commercial firms, and its modules are not prepared to serve the needs of a manufacturing industry. Therefore, the development of a MRP software consumes a lot of time and costs, and it would be more beneficial for the company to buy an MRP module that could be integrated in its ERP system. According to Lareau (2003, 127), many companies fail to understand that excessive customization may lead to the formation of a very rigid technological system that is not able to quickly respond to changes in the business. Instead of adapting the ERP software to the current processes, companies should reengineer these whenever change is inevitable.
- **Acquisition of a Product Data Management (PDM) software** – In a knowledge-intensive company like the one being analyzed, it is crucial to effectively manage information and knowledge. The implementation of a PDM software would provide an integrated mechanism for controlling and evaluating progress in a product development cycle.

- **Acquisition of a web-based ERP system** – The implementation of a web-based ERP software would enable the integration of information that is produced in other systems.
- **Structuring of a plan for the implementation of IT changes** – As it should happen with every change project, modifications to the IT systems need to be carefully planned and monitored by a cross-functional team such as the Change Committee. By tracking the observed effects of the implementation of a measure over time, it is possible to group historical records of performance that will eventually serve as a decision tool for managers.

4.4 Cost-Benefit Analysis

The improvement suggestions that were presented need to be subject to a cost-benefit analysis, through which they are classified according to parameters like relevance for the company, required time of implementation, associated cost, level of collaborative effort of different functional units, and risk. Once ranked according to these criteria, the suggestions may be included, in the future, in an execution roadmap that defines the main phases, milestones and resources associated with its implementation.

Annex AF represents in a simple and visual way how the proposed projects impact each of the factors that were considered for the analysis. The fuller is the circle, the greater is the influence of the respective factor. Ideally, a project has a great relevance for the company, does not take very long to be implemented, does not have many associated costs and risks, and does not require a big collaborative effort of employees from many different functional unis. There are, however, some trade-offs. For instance, a very relevant project has usually a big impact in the whole company, therefore requiring a bigger collaboration between employees from all departments, a situation that may be difficult to manage.

Taking into account these factors, the change projects were ranked, in which the first ones could be more readily implemented. The ranking has the following order: "A More Visual Office Layout", "A More Effective Problem Solving Method", "A New Approach to Process Management", "A Better Control of Demand and Stocks", "A More Adequate Organizational Structure", and "A More Adequate Approach to the Technological Support".

5 Conclusions and Future Work Recommendations

The project in which this dissertation was based on was developed in a five month period, during which a research work was conducted with the goal of presenting, at the moment of its conclusion, a model for change that could be implemented in the company in a near future. Research questions were formulated at the beginning of the project, acting as guidelines for its execution in a way that they could be answered once it was finished. Therefore, this final chapter of the dissertation explains the conclusions that were drawn during the investigation project, which consist in the answers to the research questions. These are followed by the description of future work recommendations, concerning the necessary tasks for a structured and successful implementation of the suggested changes.

The initial step of this project was related to the first research question, which proposed the characterization of the problems that the company has had in recent years. It was verified that the main difficulties that it has been facing are associated with the lack of control over the progress of projects that are commissioned by clients, a situation that is reflected in the late detection of problems, usually at the construction site.

Following a research methodology that comprised both quantitative and qualitative investigations (in the form of data analysis and informal interviews/direct observation, respectively), it was possible to identify the root causes of the problems, thereby answering the second research question. The main problems of the company stem primarily from a weak organizational structure and design that, if properly functioning, would provide a suitable working environment which, in turn, would increase the perception that employees have of how work is being performed across the company. This type of organizational structuring concerns the way that a company defines its rules and procedures, how it assigns tasks and responsibilities between employees, the manner with which the workspace is set up, and the mechanisms that are employed in the monitoring of work. These different dimensions are part of a company's management and quality systems, which were also subject to analysis and included in the improvement suggestions.

The topic of employee's awareness of the overall performance of the company resonates with the third research question, which asks whether there are bottlenecks that significantly affect the flow of work across different functional units. The utilization of visual tools like responsibility matrixes and VSM enabled the detection of constraints that require a big effort from employees in terms of workload, processing of information, and interfaces between employees from diverse departments. Three phases of the usual stream of work were identified as operational constrictions: the elaboration of a budget proposal, the technical treatment of an approved project, and the control of on-going projects.

The finding of the referred bottleneck activities made it possible to address the next research question, which revolves around the determination of which current aspects of the company could be improved. Having performed an analysis of the root causes of problems and the sources of operational inefficiency, the next step consisted in formulating suggestions for improvement, which were ranked according to the benefits and difficulties of its implementation.

It was considered that the most relevant aspect to be improved was the one relative to the root cause of the majority of problems – the difficulty in tracking the progress of work as it is executed. This situation is due to not only to the absence of a visual mechanism that effectively deals with the great amount of information that is present in knowledge-intensive, project-based companies, but also to the weak organizational structure, that is reflected in the excessive

amount of departments, and in the imbalanced span of control of employees. Besides this dimension, others were deemed as significant in a long term improvement perspective, regarding the definition of the company's portfolio, the way that it codifies its products, and the technological support systems it adopts.

The definition of the improvement opportunities consisted in the required step from which it was possible to answer the last research question, concerning the practical aspect of the dissertation, i.e., the development of recommended procedures in the form of templates. Contrary to the main suggestions, those that were classified as additional considerations were only briefly described because they do not directly address the root sources of the reported problems, and due to implying a higher risk, cost, and implementation time. Therefore, they are included in this final chapter as future work recommendations, requiring a careful planning and examination in the long run.

The improvement suggestions that were detailed in this dissertation can be enunciated in a succinct manner: the adoption of a multidivisional structure that prioritizes the integration of knowledge across the company; the creation of an *Obeya* Room where the state of different projects is tracked on a daily basis and problems are solved in a continuous improvement approach, through the use of A3 reports; the definition of process-oriented KPI; and the reengineering of core processes so as to instill responsibility, discipline and ownership in employees.

Future work recommendations relate to the additional considerations, and are explained as follows:

- **Restructuring of the codification system** – This type of change takes a long time and requires the collaboration of people from different functional units, so that different points of view can be discussed in brainstorming sessions. The main goal of such project would be to decrease the variability of products and to continuously reduce the codification errors that are usually detected at the moment of stock picking and dispatch.
- **Limitation of product offer** – This suggestion is also related to the reduction of variability within the company, in this case the one that is due to demand. The redefinition of the company's product offer should be of managers' responsibility, with the valuable input from commercial managers and marketing employees.
- **Implementation of visual management at the warehouse facilities** – Some visual management tools should be implemented in the warehouse facilities so that they become more organized. It is recommended the development of a project with the goal of redesigning the warehouse layout.
- **Updating of documents of the quality management system**– The reengineering of the company's core processes and its quality control mechanisms require the reformulation of its current quality management system documents. It is recommended that these documents are as simple and brief as possible, and that more detailed texts are produced only for complex work instructions.
- **Preparation for the revision of the quality norm ISO 9001:2015** – The company is certified with this quality norm, which is going to be updated at the end of the current year. Therefore, the company has to adapt its processes to the modifications, which consist mainly on placing a bigger focus on processes, leadership, and risk management (TÜV Rheinland Portugal, 2015).
- **Adequate training of employees** – The implementation of the suggested measures implies that employees are given appropriate training so that they are able to take on

new responsibilities. This training process should be a continuous learning experience, and not just a series of brief workshops that are performed at the beginning of the change program. Employees have to understand and accept the changes that are to be implemented, and should be given the opportunity to contest them and suggest alternatives, which in turn have to be carefully taken into account by managers.

In conclusion, this dissertation aims to be the starting point from which change projects can be implemented in the company, following a continuous improvement approach.

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ANNEX A: Business Model Canvas

Key Partners

- Suppliers of components and equipment
- Trading partners
- Educational institutions
- Incentives programs and institutions
- Specialty magazines

Key Activities

- R&D
- Project budgeting
- Outsourcing of components and equipment
- Contract management
- Sourcing

Key Resources

- Technological know-how
- Knowledge of market and product characteristics/tendencies
- Multidisciplinary teams
- Patents and trademarks
- Design software licenses
- Good understanding of English, French and Spanish

Value Propositions

- **Customized and high-quality technical furniture and equipment for laboratorial settings**
- **Turn-key projects of integrated solutions for laboratorial settings**
- **High-tech controlling and monitoring of laboratorial settings**

Customer Relationships

- Quick response
- Lower prices than the ones of competitors
- Customization of products
- After-sales service
- Express service
- Client satisfaction surveys
- Newsletter

Channels

- Project managers
- Commercial agents
- Subsidiaries
- Construction supervisors
- Exhibition fairs

Customer Segments

- **Industrial companies that are in need of new technical furniture and equipment for laboratories**
- **Industrial companies in need of brand new laboratorial spaces**
- **Industrial companies that want to keep up with laboratorial state-of-the-art**

Cost Structure

- Outsourcing of components and equipment
- Outsourcing of engineering and technical services
- Production of components
- Transportation of material
- Design software licenses

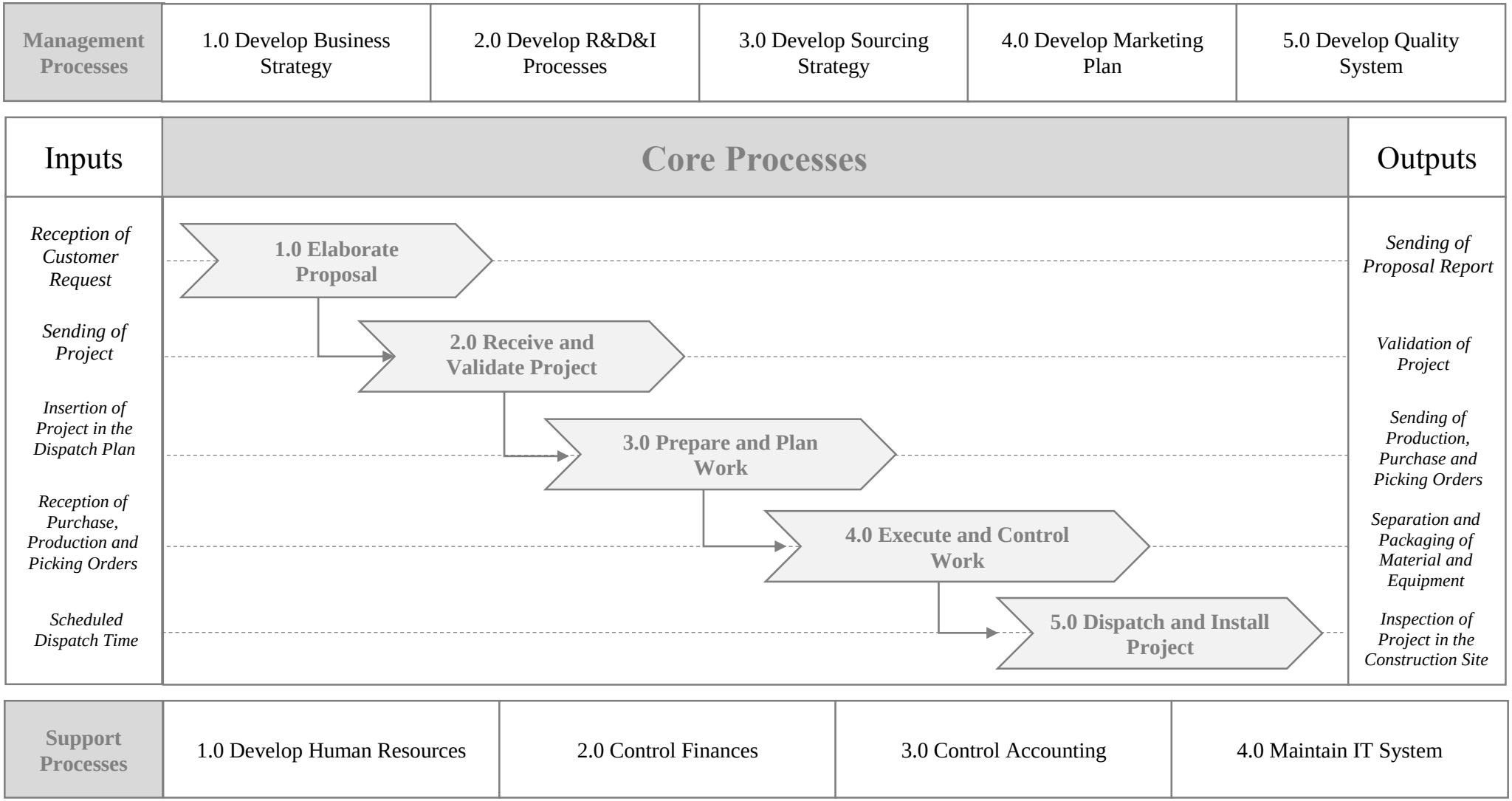
Revenue Streams

- Commissioned projects from national markets
- Commissioned projects from international markets
- Maintenance contracts
- Royalties from trading partnerships
- Innovation awards

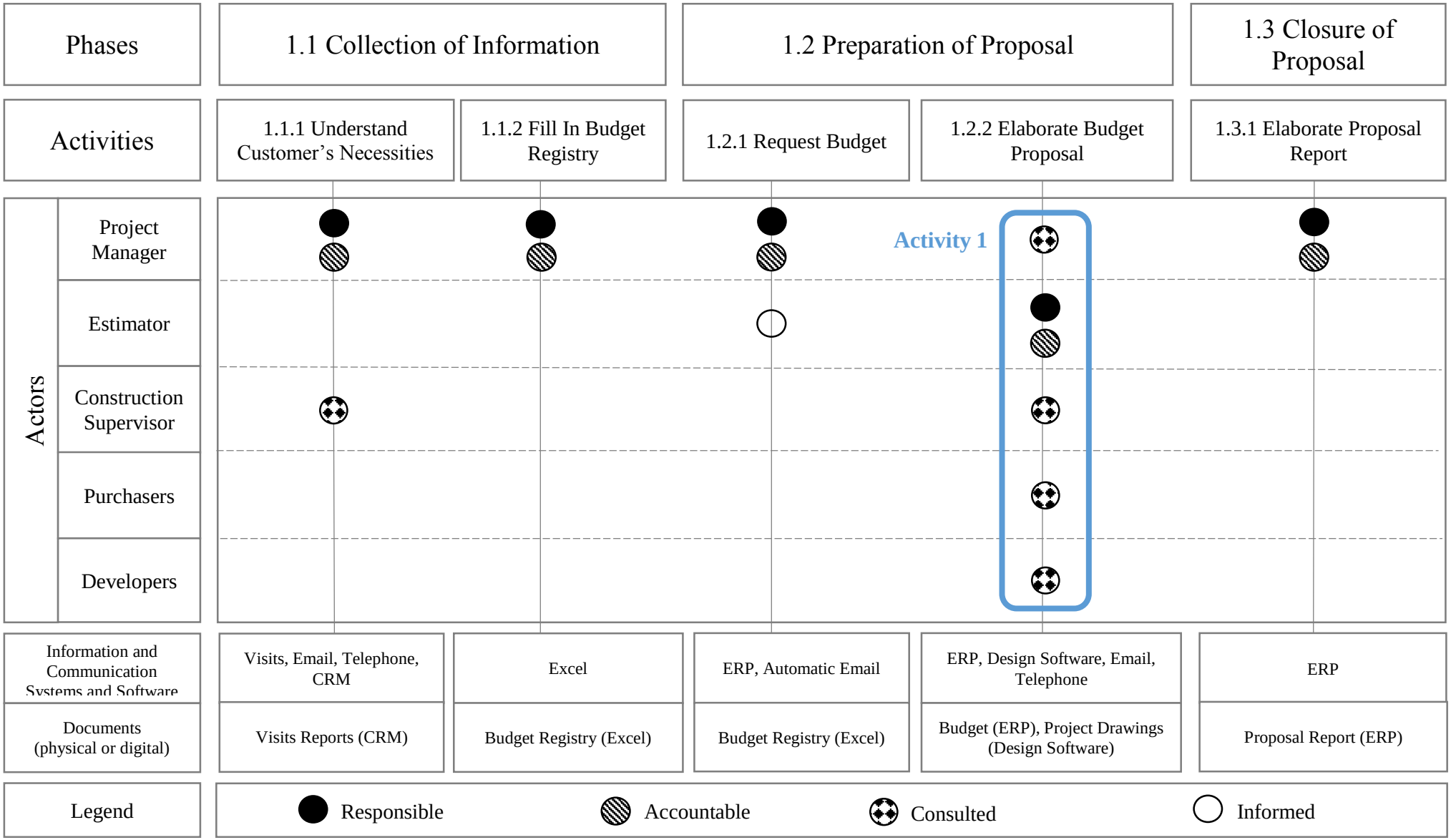
ANNEX B: SWOT ANALYS

Strengths	Weaknesses
• **Order Winners:** highly flexible and customized offer, quick response to customers; • **Technology:** advanced technological development for intelligent laboratories; • **Knowledge:** multidisciplinary teams.	• **Communication:** poor interdepartmental communication; • **Quality Management System:** ineffective problem solving method; • **Software:** inadequate MRP, excessive dependence on ERP, frequent ERP errors; • **Stock:** significant inconsistencies between physical and virtual stock; • **Quality of Products:** frequently damaged and/or defective material; • **Visual Management:** disorganized warehouse facilities and offices; • **Leadership:** poor focus and discipline, micro-management.
Opportunities	**Threats**
• **Internationalization:** expansion into new markets and countries; • **Industrial Property:** creation of patents for technologically developed solutions; • **Alliances:** formation of new partnerships with suppliers and educational institutions; • **Facilities:** moving offices to recently acquired facilities.	• **Regulations:** revision of NP EN ISO 9001:2008, and/or implementation of NP EN ISO 14001:2012 may require the reformulation of processes; • **Markets and Customers:** changes in market needs and increasing variability of solutions to customers requires the strengthening of competitive advantages; • **Suppliers:** loss and/or deterioration of strategic relationships with suppliers, and/or poor quality of supplier services may affect product quality and compliance with deadlines; • **ERP Software:** increasing software errors associated with an excessive dependence on the ERP may compromise the company's stability.

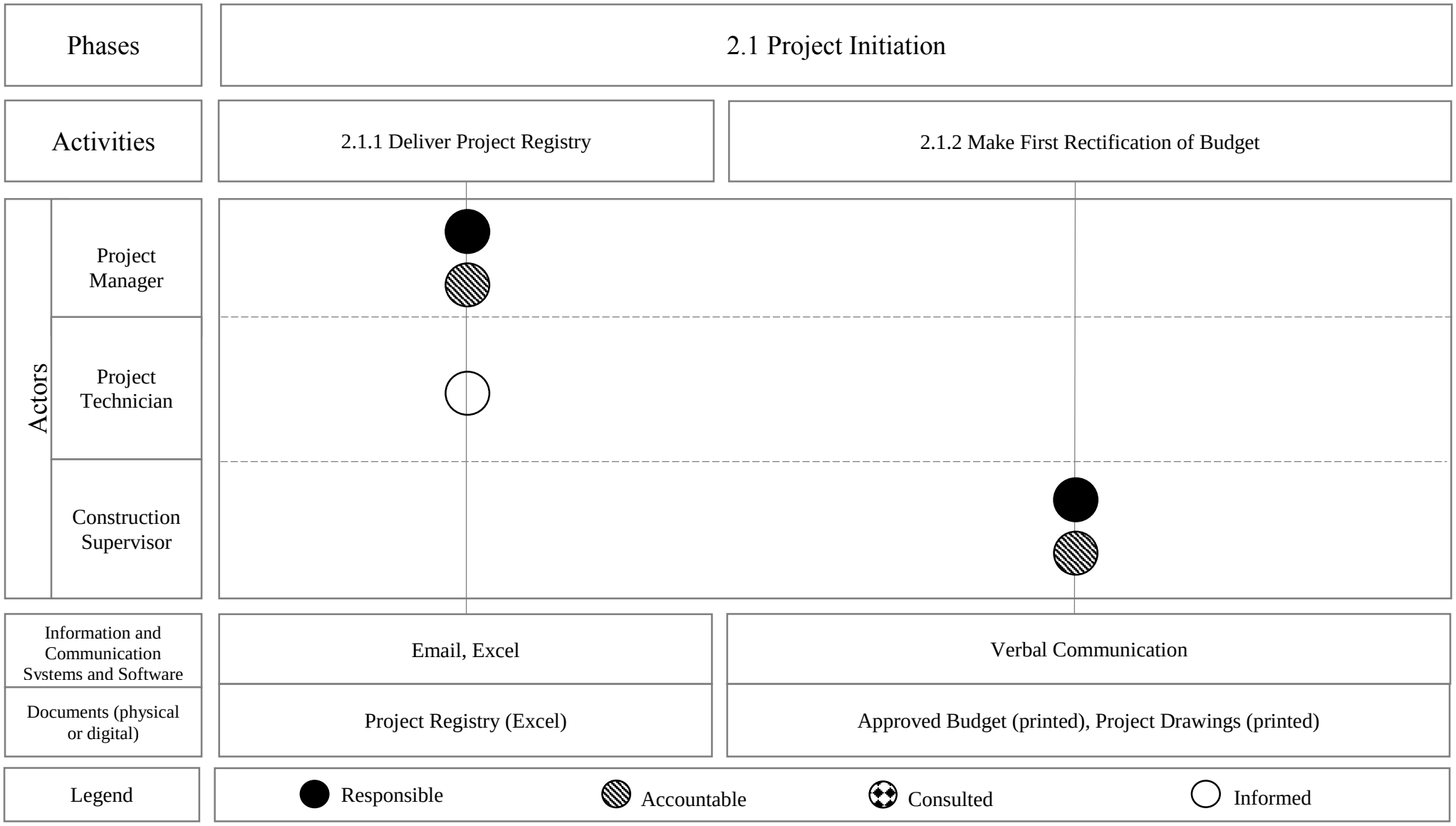
ANNEX C: As-Is Business Processes Map



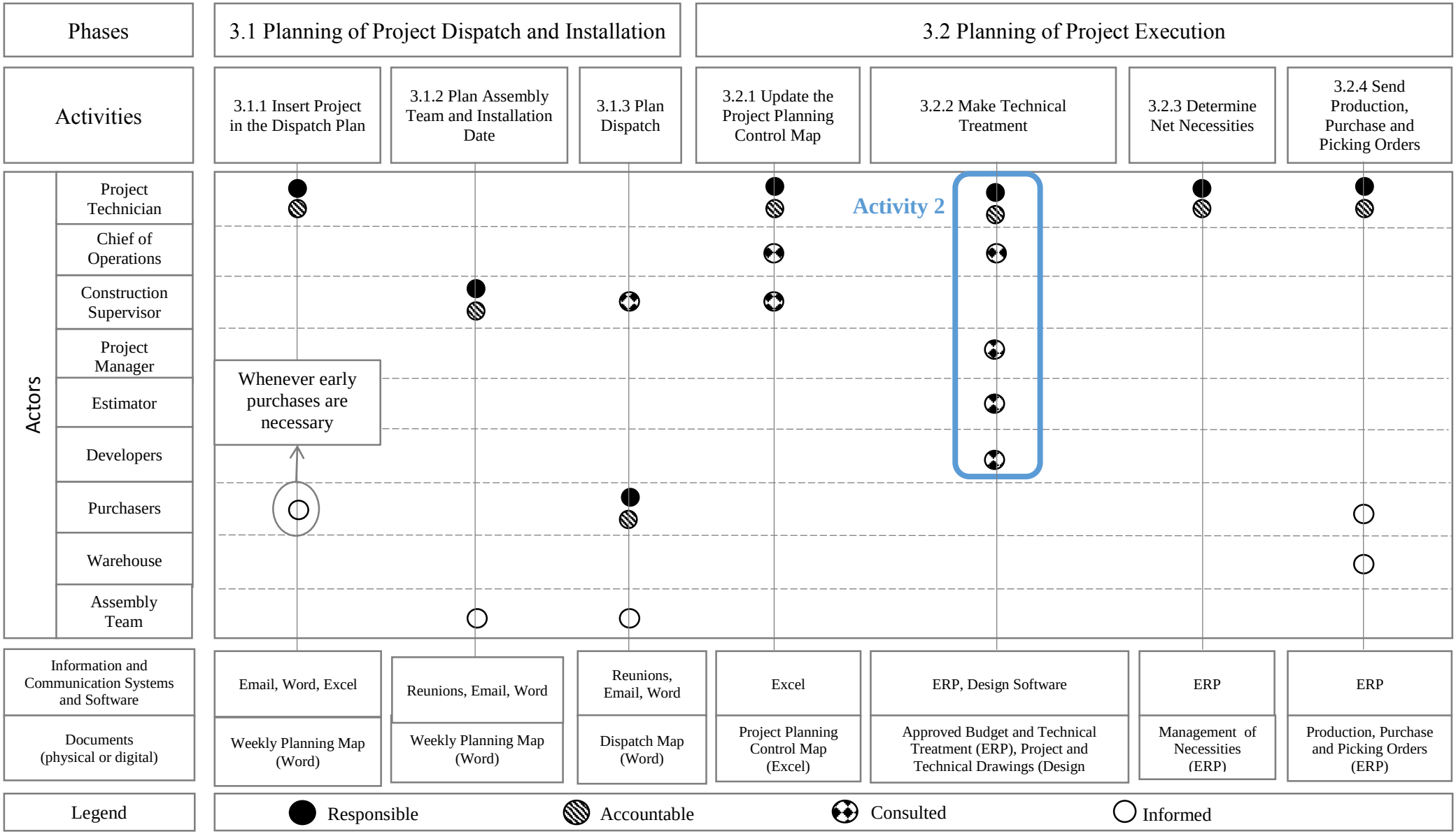
ANNEX D: As-Is Responsibility Matrix – Process 1.0 Elaborate Proposal



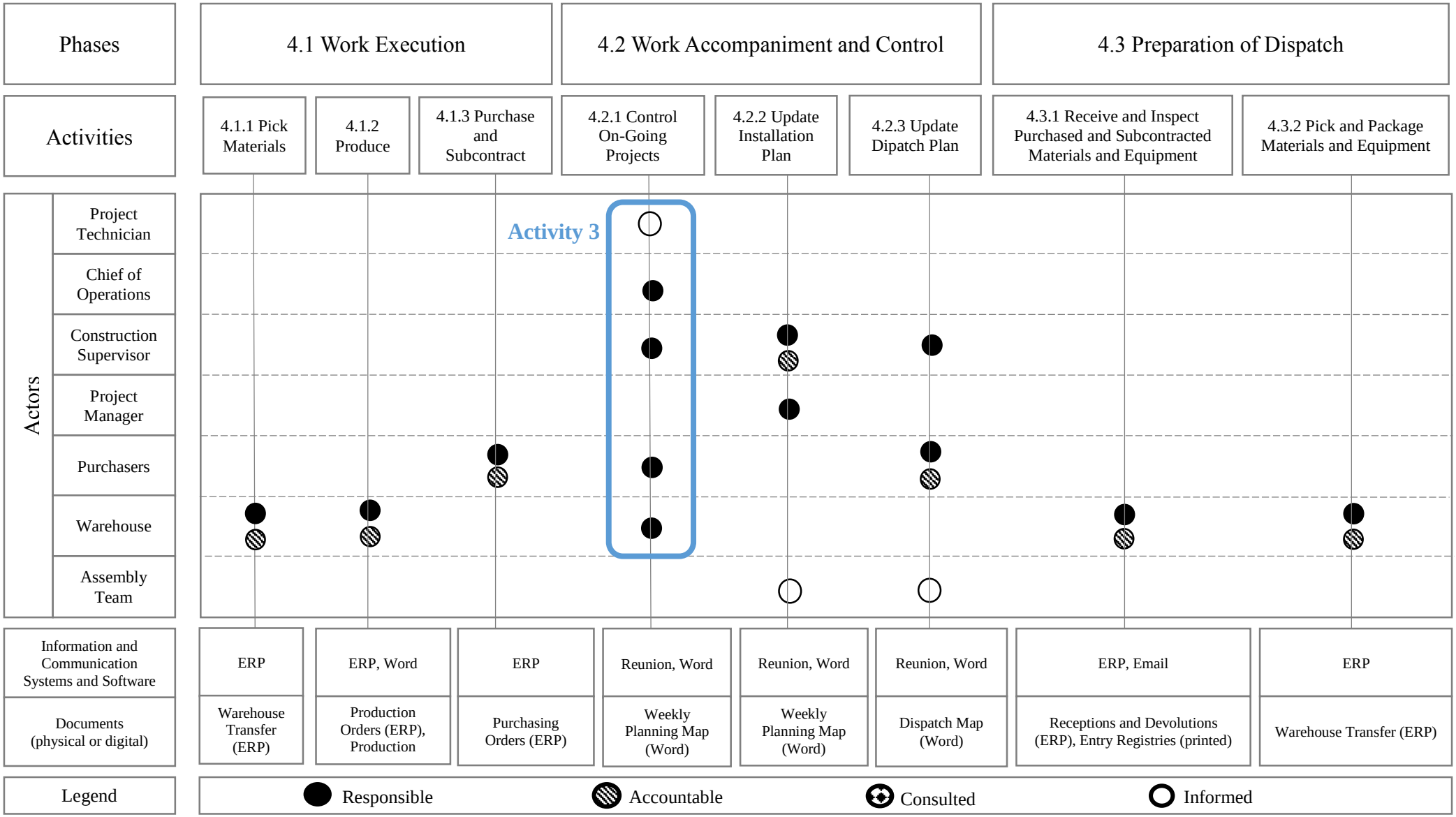
ANNEX E: As-Is Responsibility Matrix – Process 2.0 Receive and Validate Project Proposal



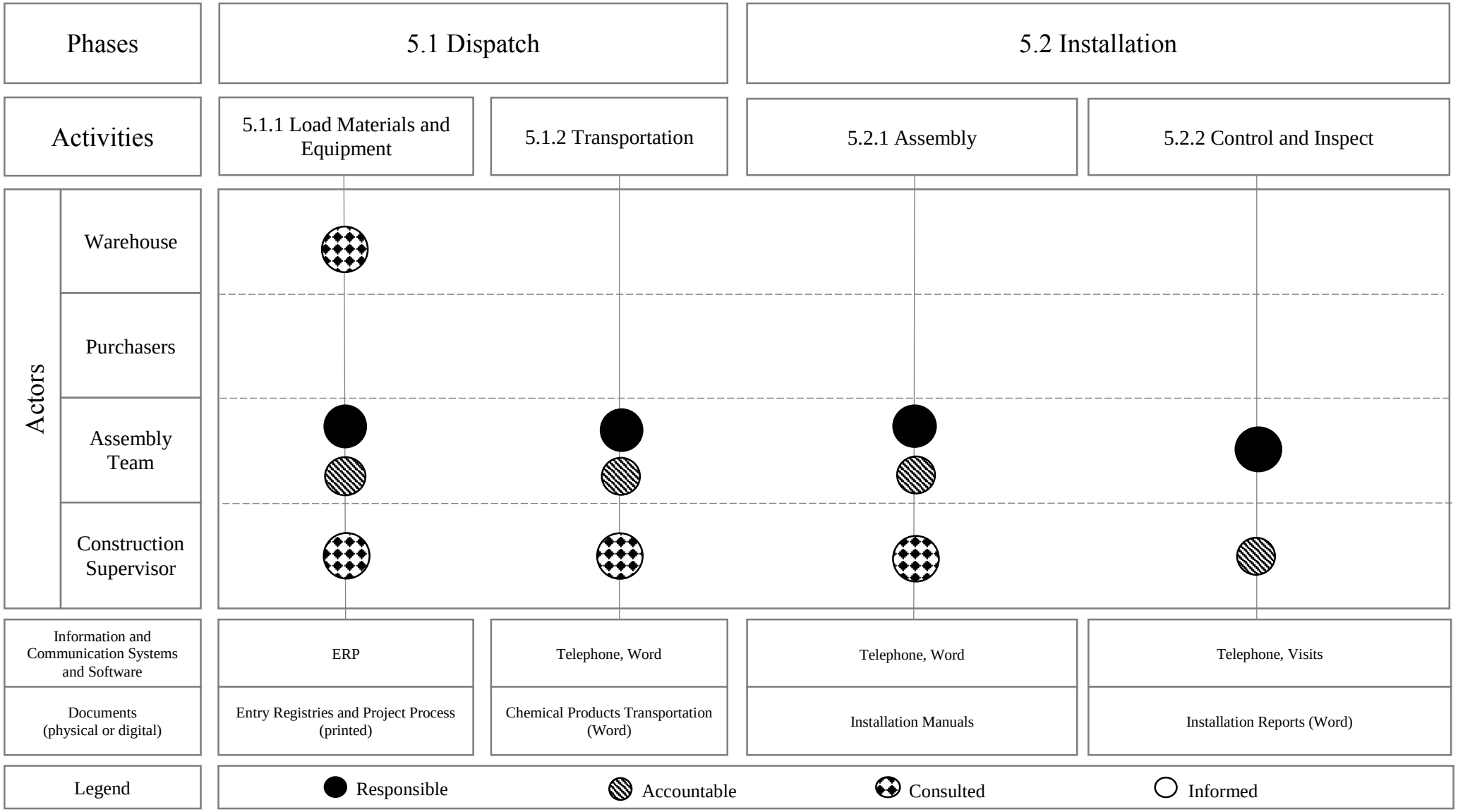
ANNEX F: As-Is Responsibility Matrix – Process 3.0 Prepare and Plan Work



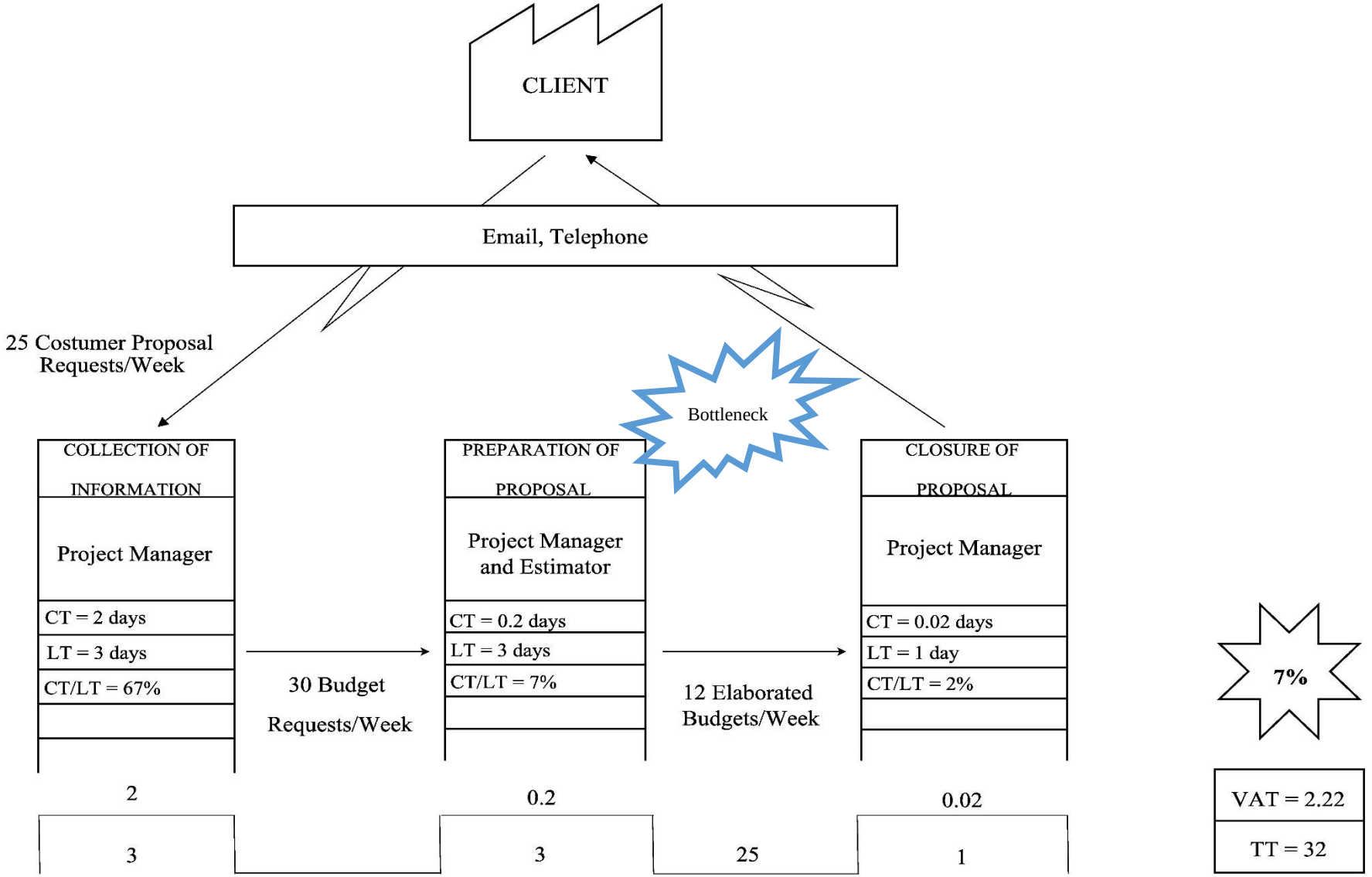
ANNEX G: As-Is Responsibility Matrix – Process 4.0 Execute and Control Work



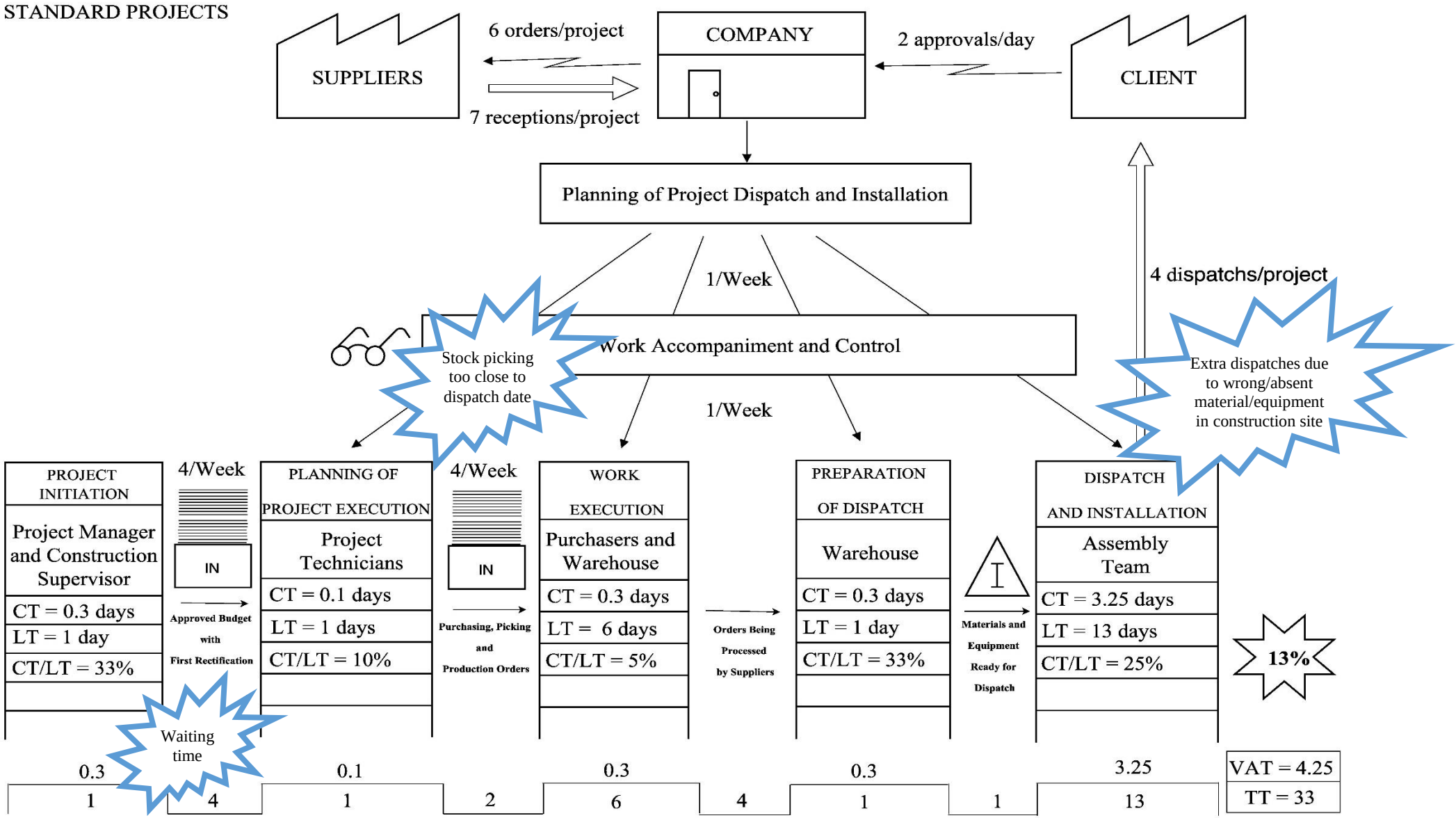
ANNEX H: As-Is Responsibility Matrix – Process 5.0 Dispatch and Install Project



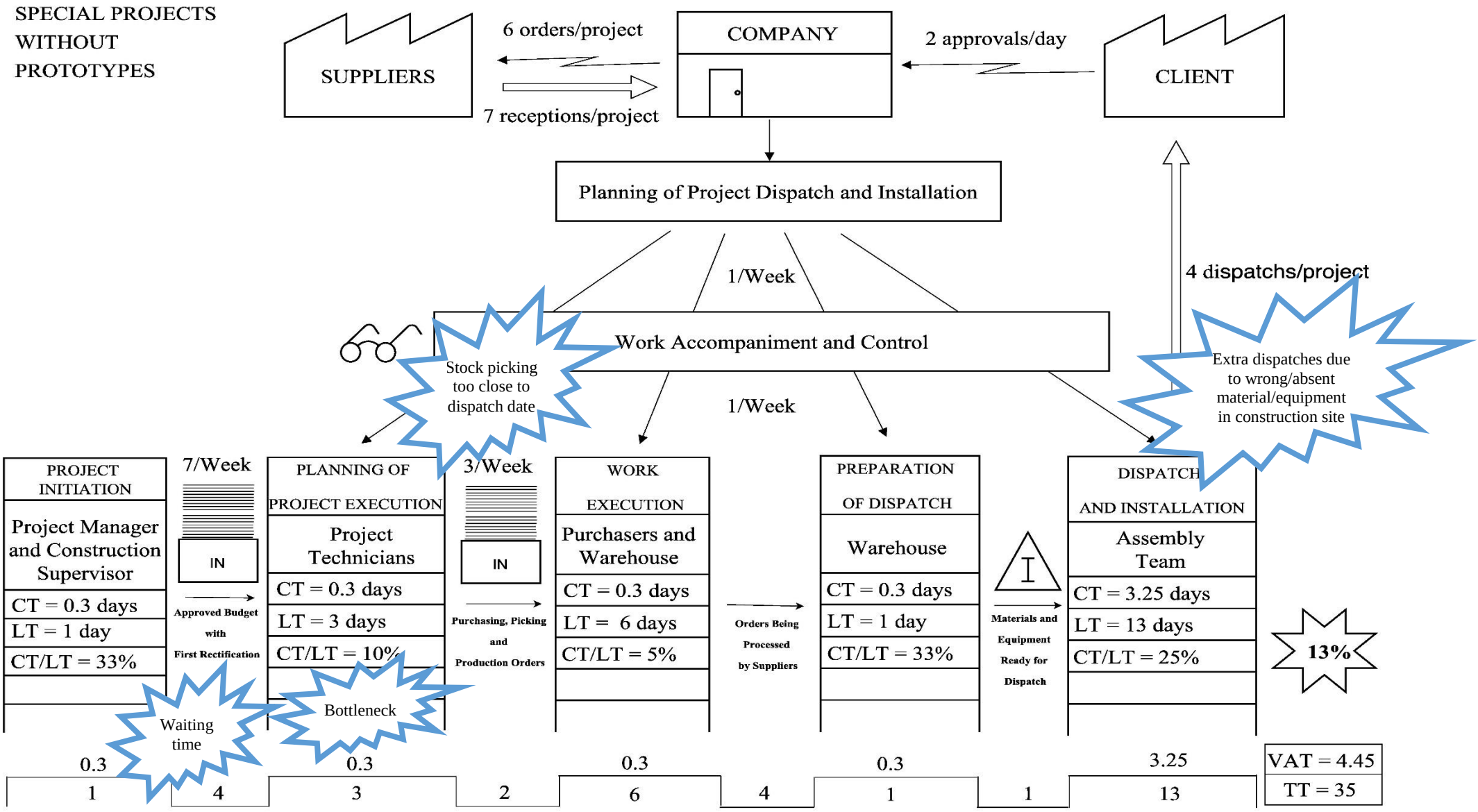
ANNEX I: As-Is VSM – Process 1.0 Elaborate Proposal



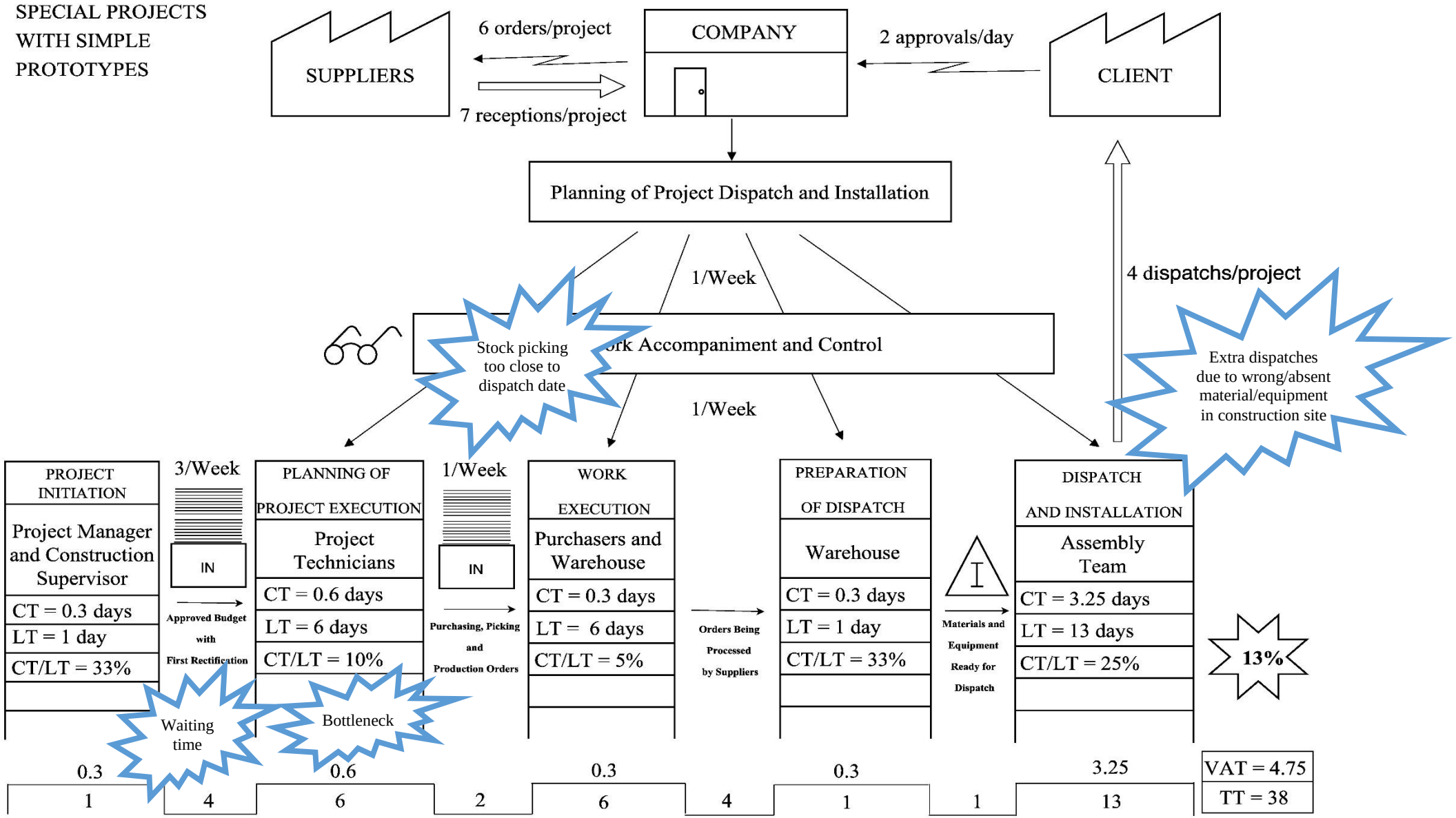
ANNEX J: As-Is VSM – Processes 2.0 to 5.0 (Standard Projects)



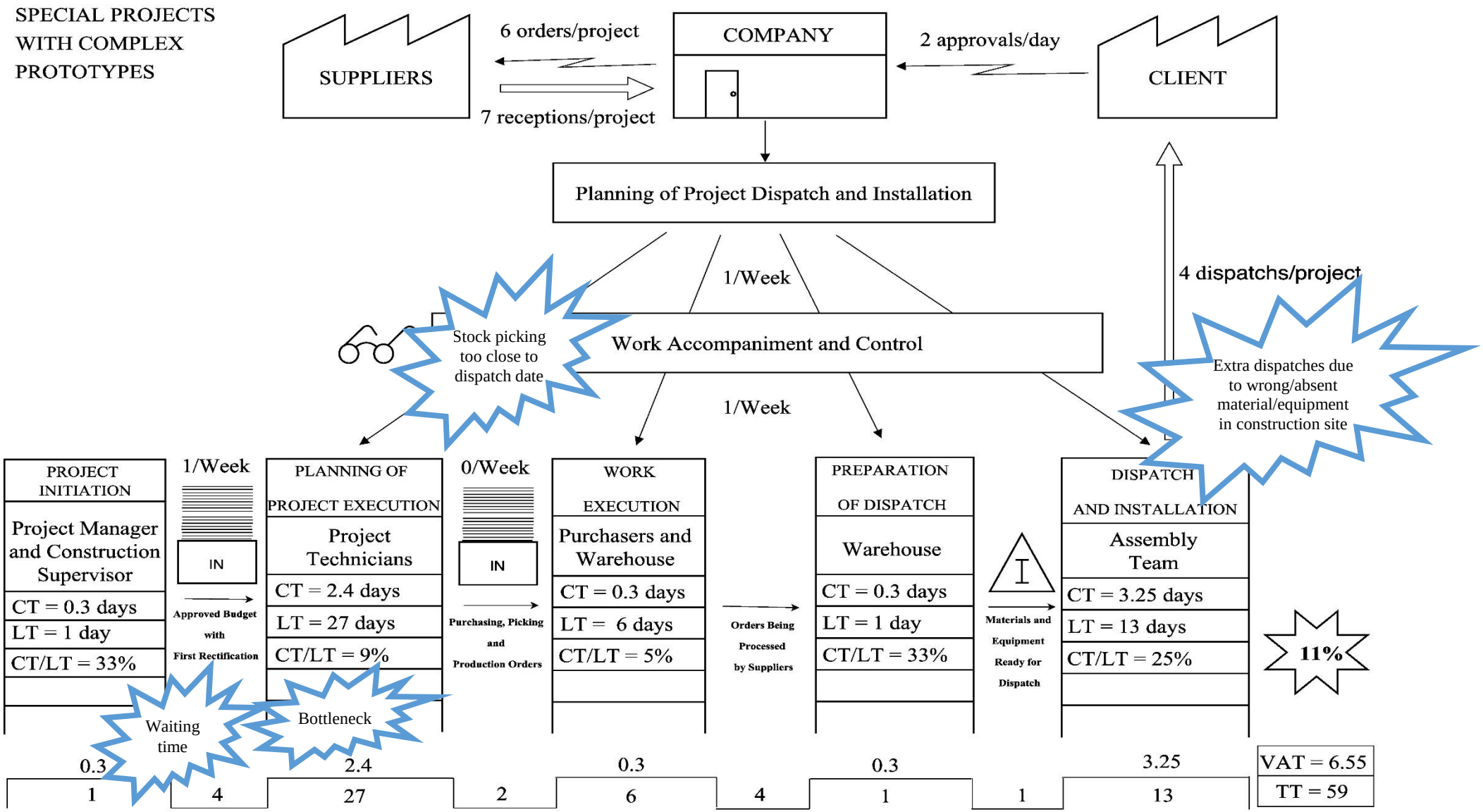
ANNEX K: As-Is VSM – Processes 2.0 to 5.0 (Special Projects without Prototypes)



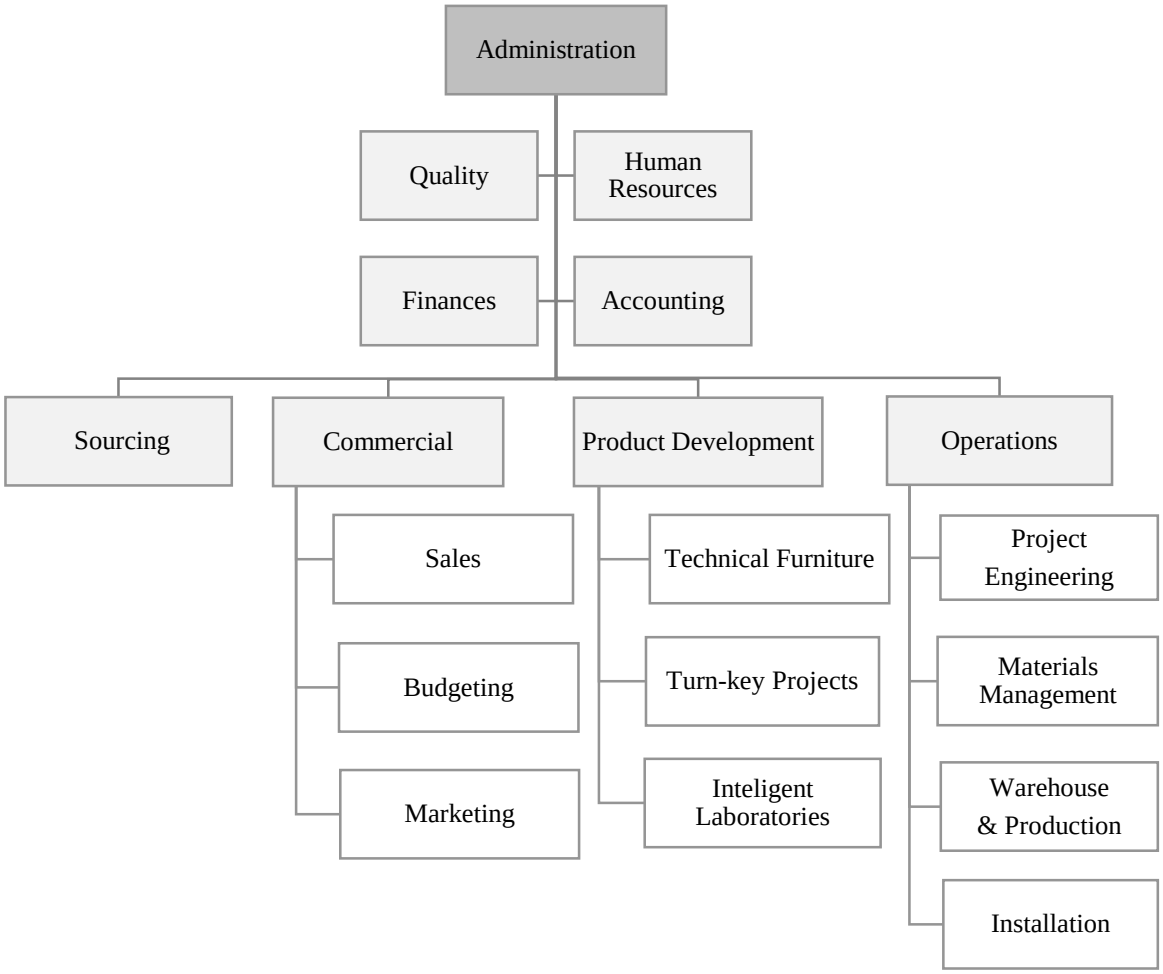
ANNEX L: As-Is VSM – Processes 2.0 to 5.0 (Special Projects with Simple Prototypes)



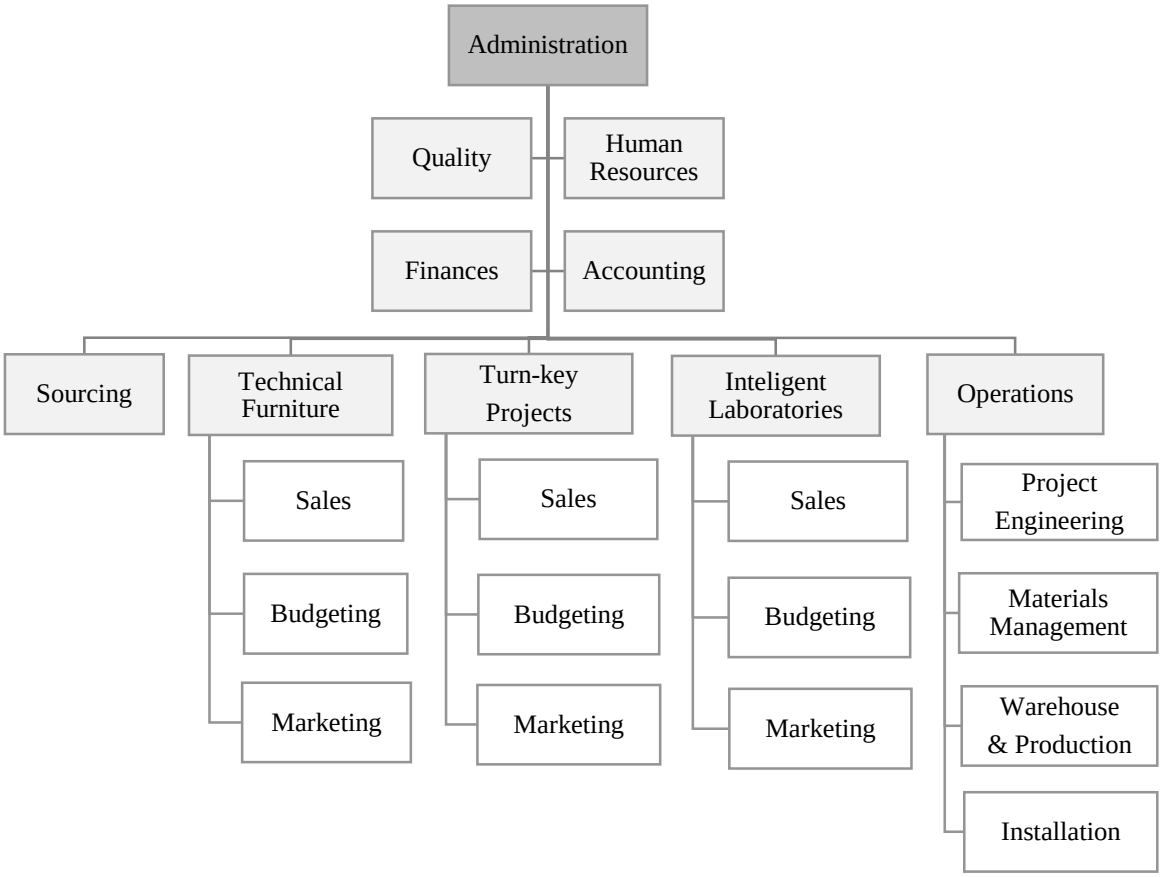
ANNEX M: As-Is VSM – Processes 2.0 to 5.0 (Special Projects with Complex Prototypes)



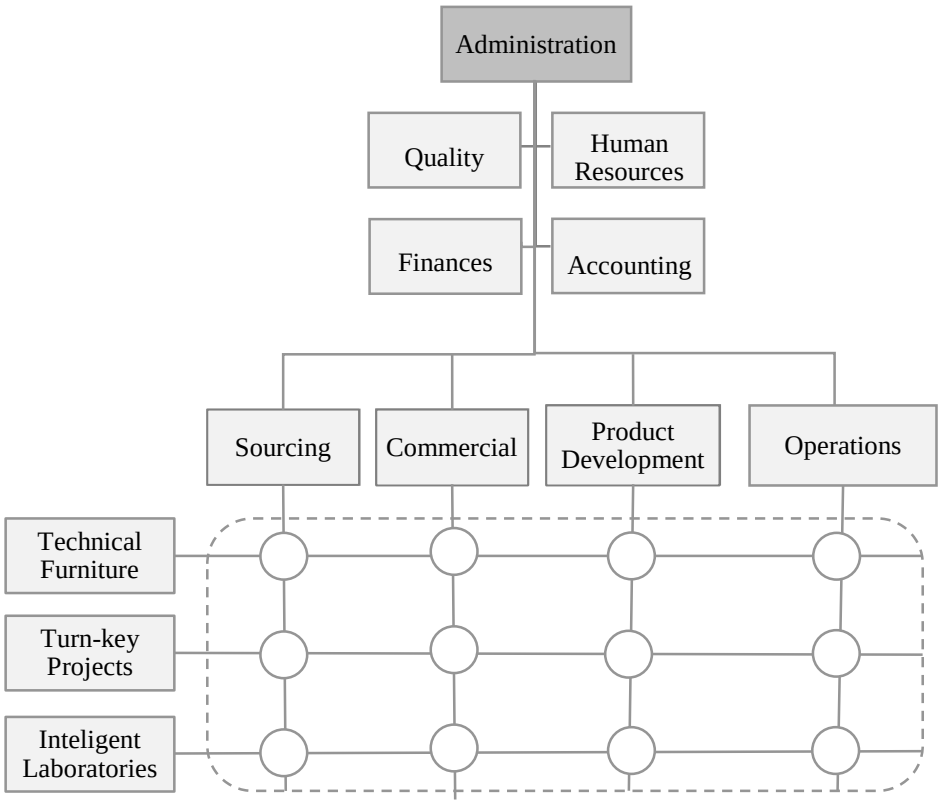
ANNEX N: Suggestion - Functional Structure



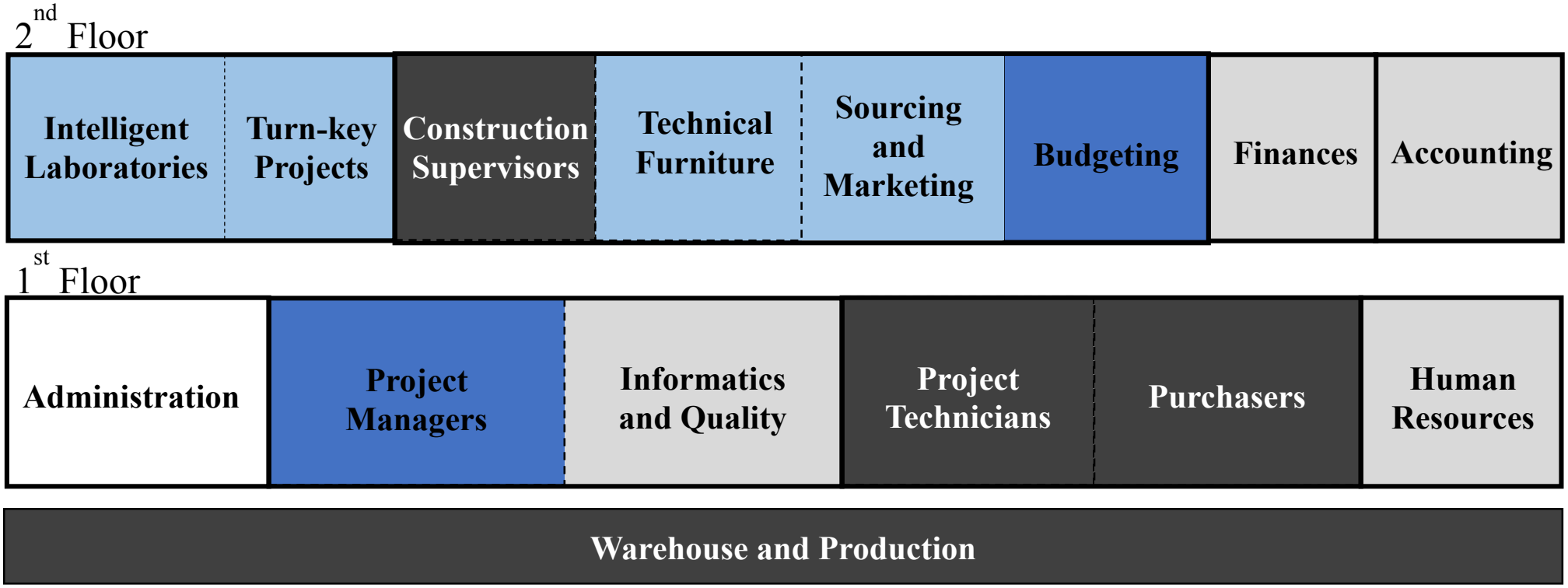
ANNEX O: Suggestion - Divisional Structure



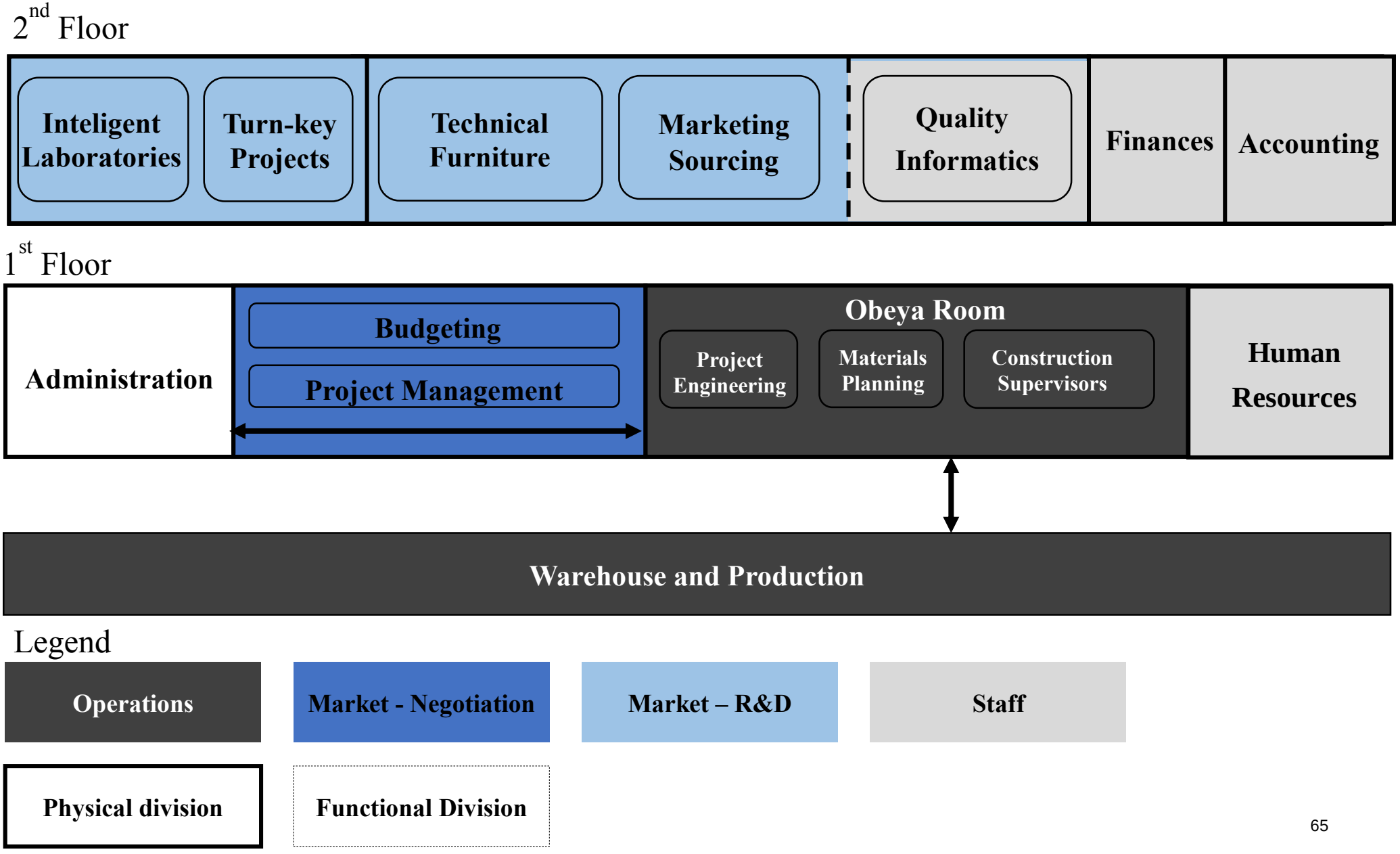
ANNEX P: Suggestion - Matrix Structure



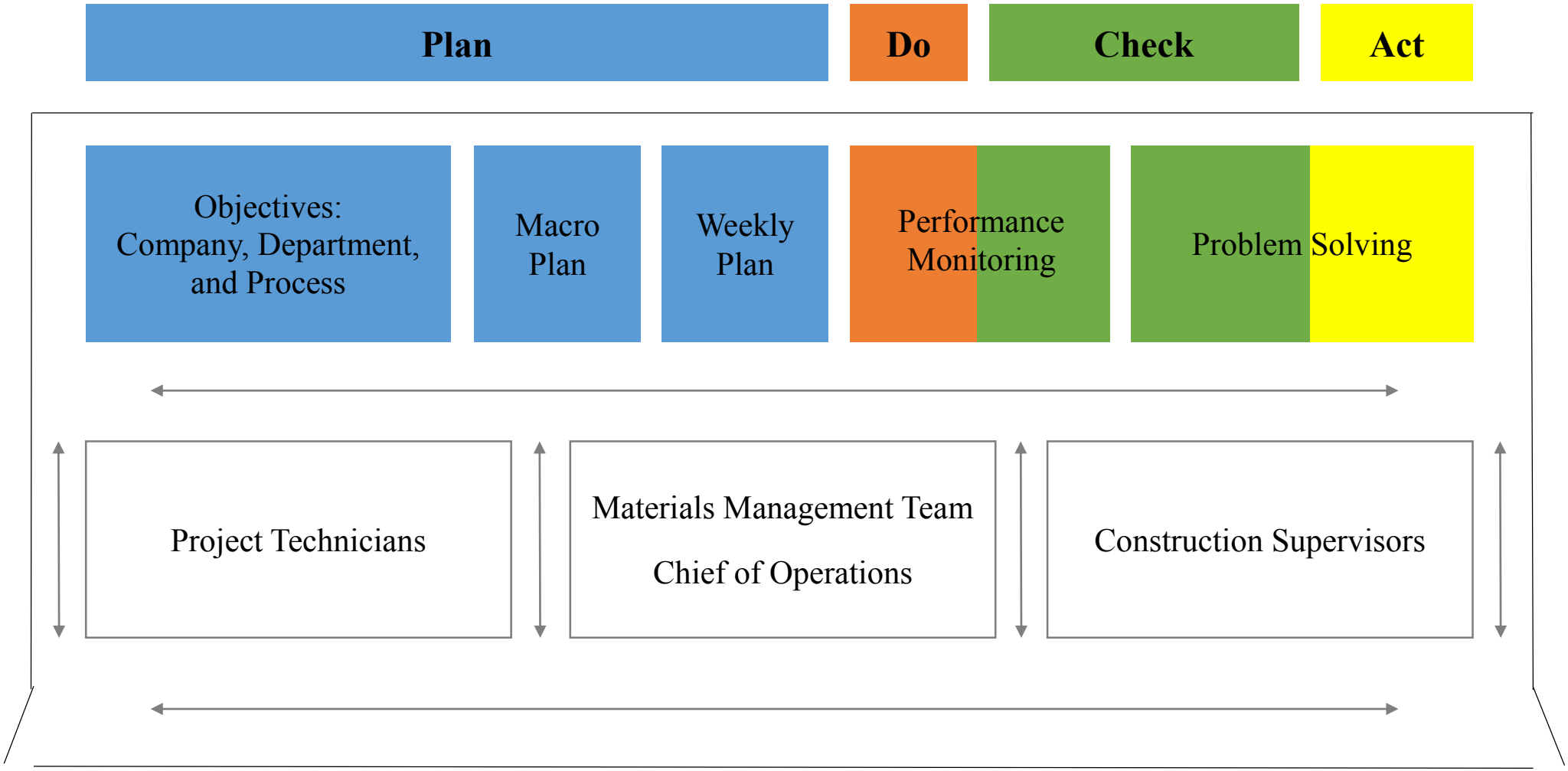
ANNEX Q: As-Is Office Layout



ANNEX R: To-Be Office Layout



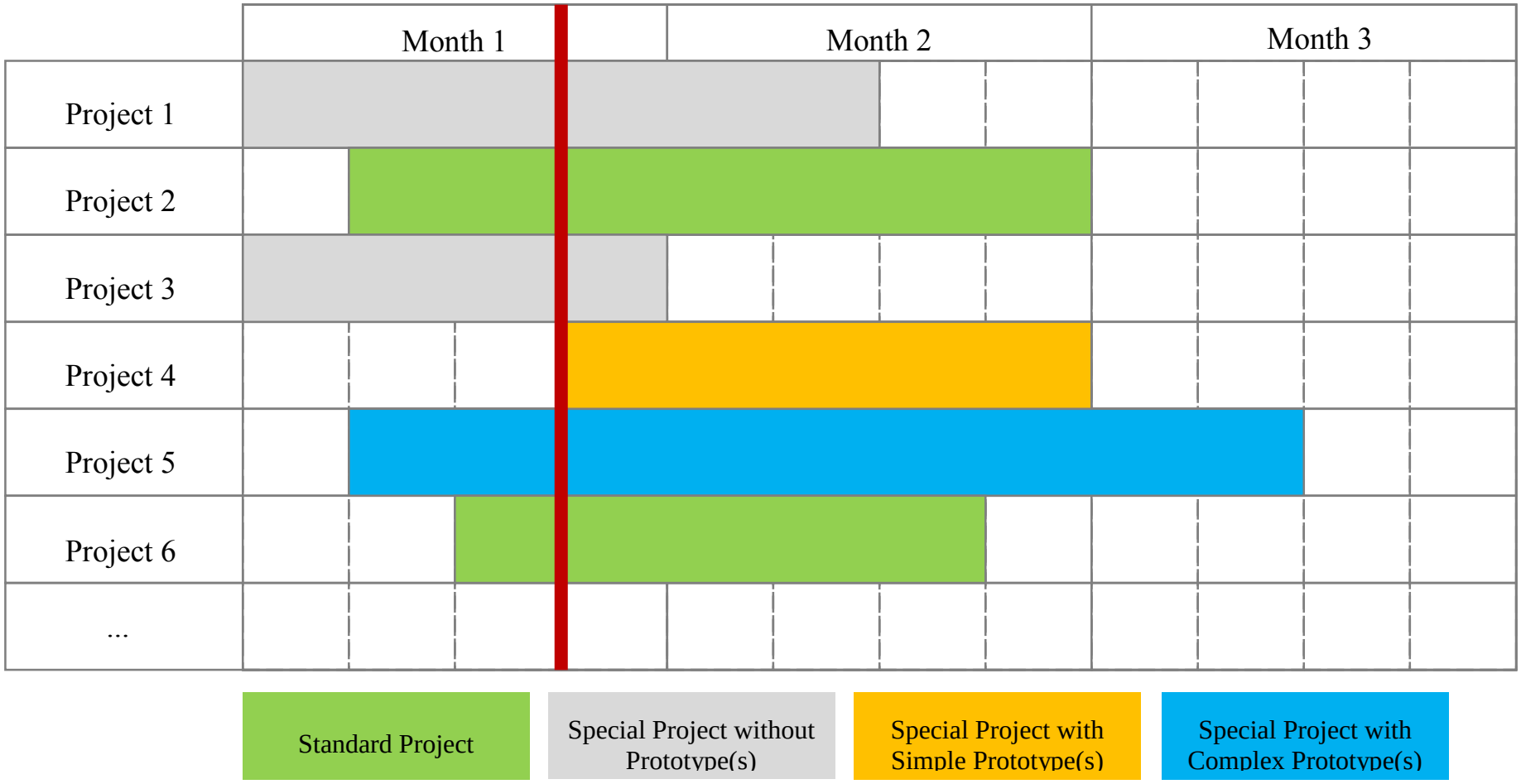
ANNEX S: To-Be Office Layout – Obeya Room



ANNEX T: Obeya Room – Template of Macro Plan Poster

Macro Plan Manager:

Last Update: ___/___/_____



ANNEX U: Obeya Room – Template of Weekly Plan Poster

Week no:					
Department: _____					
Weekly Plan Manager: _____ Last Update: ___/___/_____					
	Monday	Tuesday	Wednesday	Thursday	Friday
Project 1	Employee A				
Project 2					
Project 3					
Project 4					
Project 5					
...					

ANNEX V: Obeya Room – Template of Project Status Poster

Project Name					
Internal Project Manager: _____ Expected Dispatch Date: ____/____/_____		0%	25%	50%	75% 100%
To-Do	Deadline	In Progress	Deadline	Finished	Delivery Date
Urgent Tasks Task					
Task					

ANNEX W: Obeya Room – Template of Problem Solving Poster

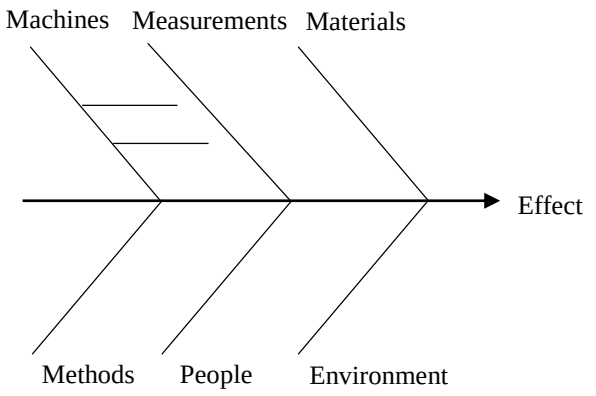
Project Title	
Project Leader	
Date	

Background

Current State

Goals

Root Cause Analysis



Proposed Countermeasures

Cause	What	Who	When	Status

Check Results

Follow-Up Actions

What	Who	When	Status

ANNEX X: Obeya Room – Template of Problem Registry

Problem Registry Number	
Date	
Reported by	
Registered by	

Type of Process

☐ C1 ☐ S1 ☐ M1 ☐ M5
☐ C2 ☐ S2 ☐ M2
☐ C3 ☐ S3 ☐ M3
☐ C4 ☐ S4 ☐ M4

Urgency Level

☐ Not Urgent (5 working days)

☐ Urgent (2 working days)

☐ Very Urgent (24 hours)

Problem Characterization

Phase of Detection

☐ 1.1.1 ☐ 2.1.1 ☐ 3.1.1 ☐ 4.1.1
☐ 1.1.2 ☐ 2.1.2 ☐ 3.1.2 ☐ 4.1.2
☐ 2.1.3 ☐ 3.1.3
☐ 1.2.1 ☐ 2.1.4 ☐ 4.2.1
☐ 1.2.2 ☐ 3.2.1 ☐ 4.2.2
☐ 1.2.3 ☐ 2.2.1 ☐ 3.2.2
☐ 2.2.2 ☐ 3.2.3
☐ 1.3.1 ☐ 2.2.3
☐ 1.3.2 ☐ 2.2.4 ☐ 3.3.1
☐ 1.3.3 ☐ 3.3.2

Type of Problem

☐ Damaged material
☐ Defective material
☐ Absence of material
☐ Wrong material
☐ Wrong codification
☐ Other:

_____

_____

Improvement Project

☐ Existing

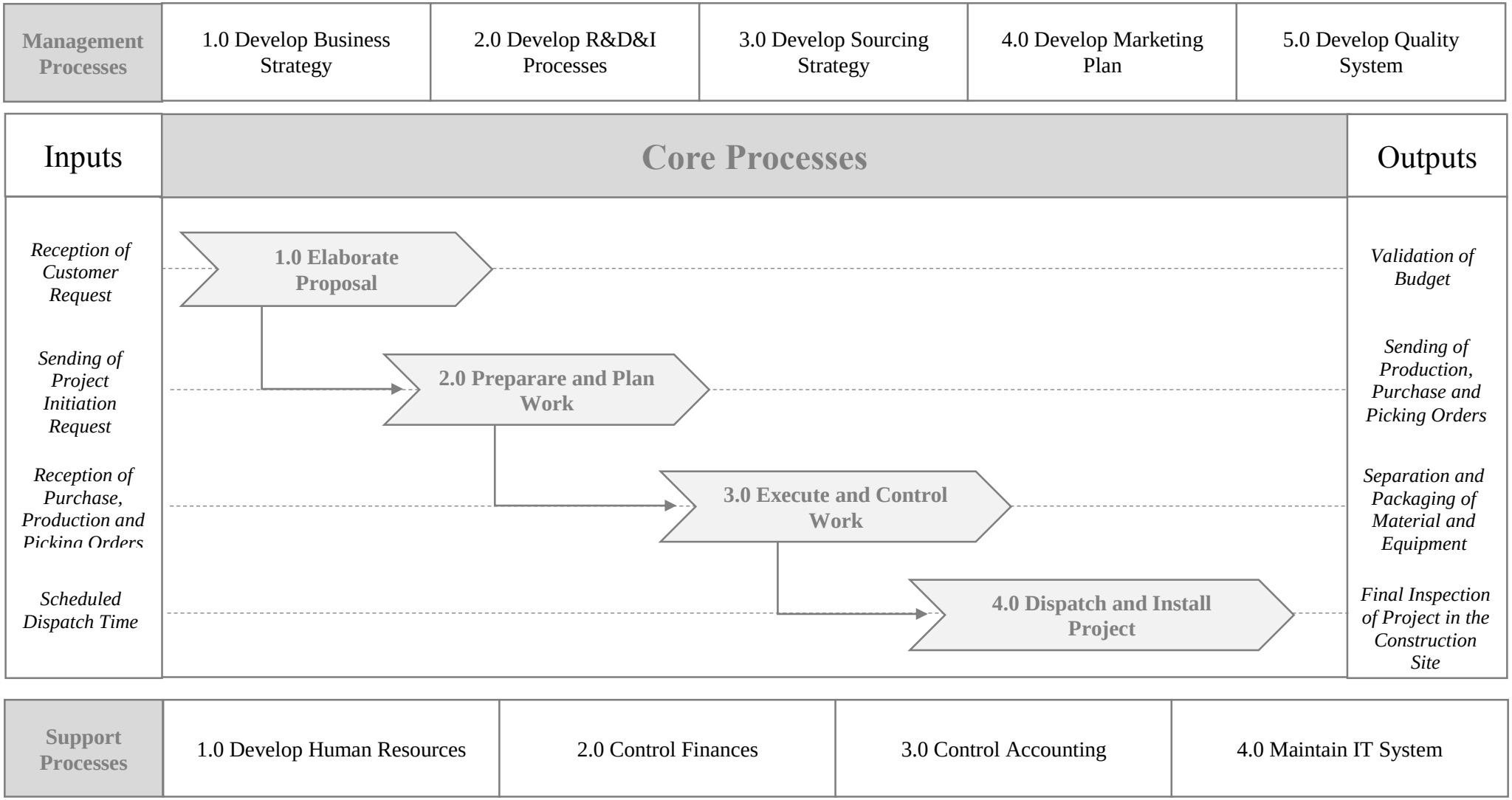
_____

☐ New Opportunity of Improvement

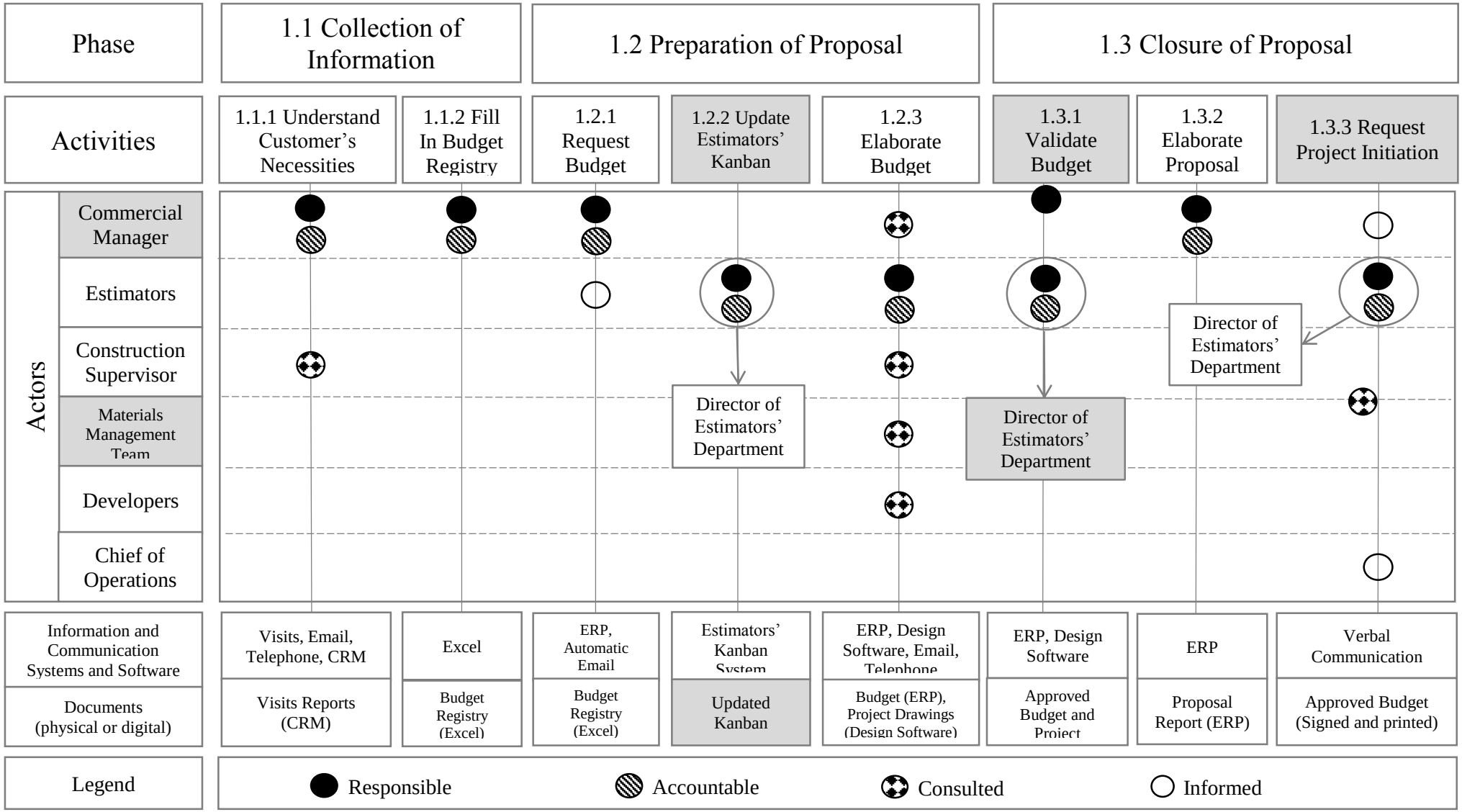
ANNEX Y: Obeya Room – Legend of Problem Registry

Legend of Problem Registry	
C1 – Elaborate Proposal C2 – Prepare and Plan Work C3 – Execute and Control Work C4 – Dispatch and Install Work S1 – Develop Human Resources S2 – Control Finances S3 – Control Accounting S4 – Maintain IT System M1 – Develop Business Strategy M2 – Develop R&D&I Processes M3 – Develop Sourcing Strategy M4 – Develop Marketing Plan M5 – Develop Quality System 1.1.1 - Understand the Customer's Necessities 1.1.2 - Fill In Budget Registry 1.2.1 - Request Budget 1.2.2 - Update Estimators' Kanban 1.2.3 - Elaborate Budget 1.3.1 - Validate Budget 1.3.2 - Elaborate Proposal 1.3.3 - Request Project Initiation 2.1.1 - Designate Internal Project Manager 2.1.2 - Plan Assembly Team and Installation Date 2.1.3 - Plan Dispatch 2.1.4 - Update Macro Plan Poster 2.2.1 - Make Technical Treatment 2.2.2 - Update Technicians' Kanban 2.2.3 - Determine Net Necessities 2.2.4 - Send Production, Purchase and Picking Orders	3.1.1 - Pick Materials 3.1.2 - Produce 3.1.3 - Purchase and Subcontract 3.2.1 - Control Stock Picking and Production 3.2.2 - Control Suppliers' Work 3.2.3 -Update Project Status Poster 3.3.1 - Receive and Inspect Purchased and Subcontracted Materials and Equipment 3.3.2 - Pick and Package Materials and Equipment 5.1.1 - Load Materials and Equipment 5.1.2 - Transportation 5.2.1 - Assembly 5.2.2 - Control and Inspect

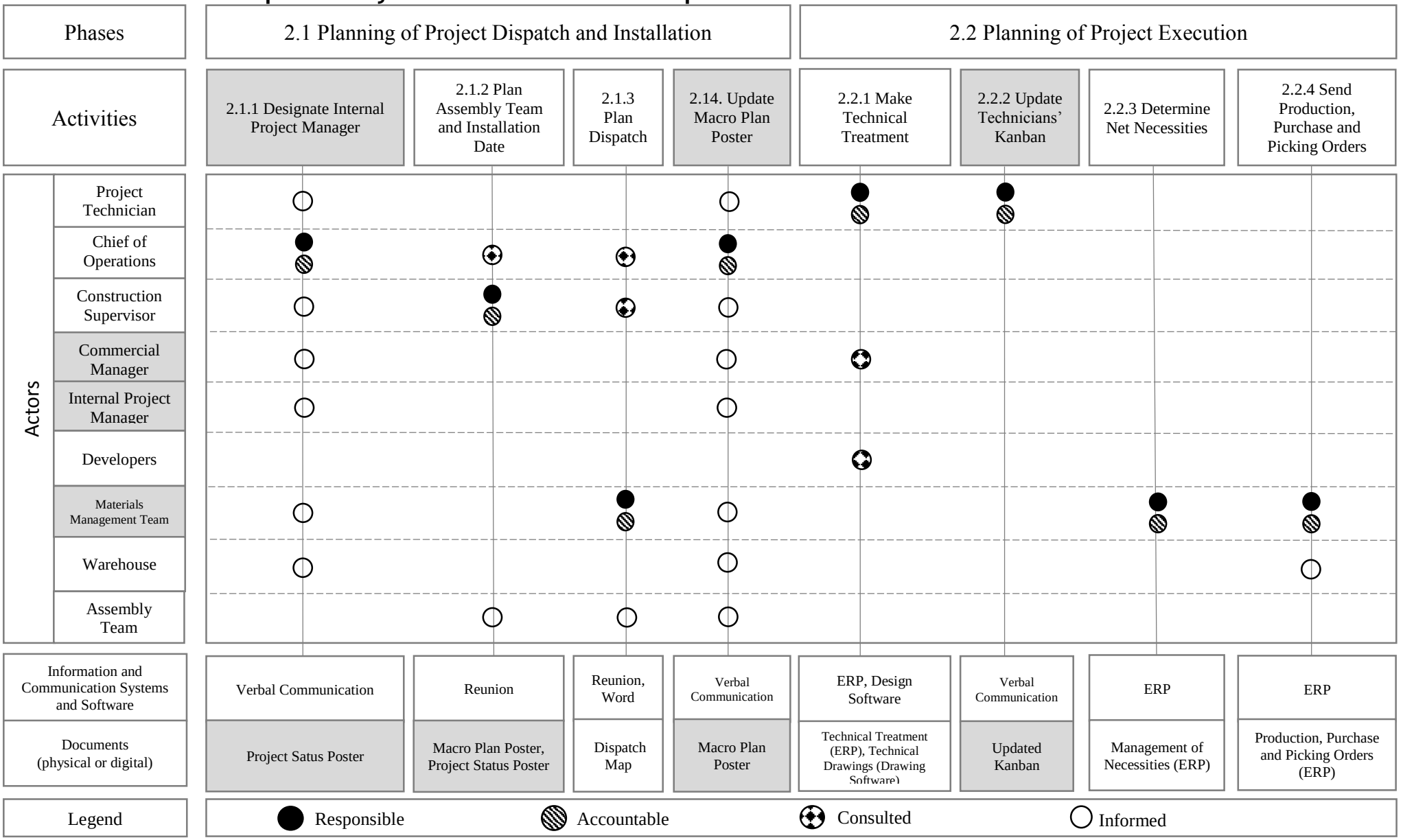
ANNEX Z: To-Be Business Processes Map



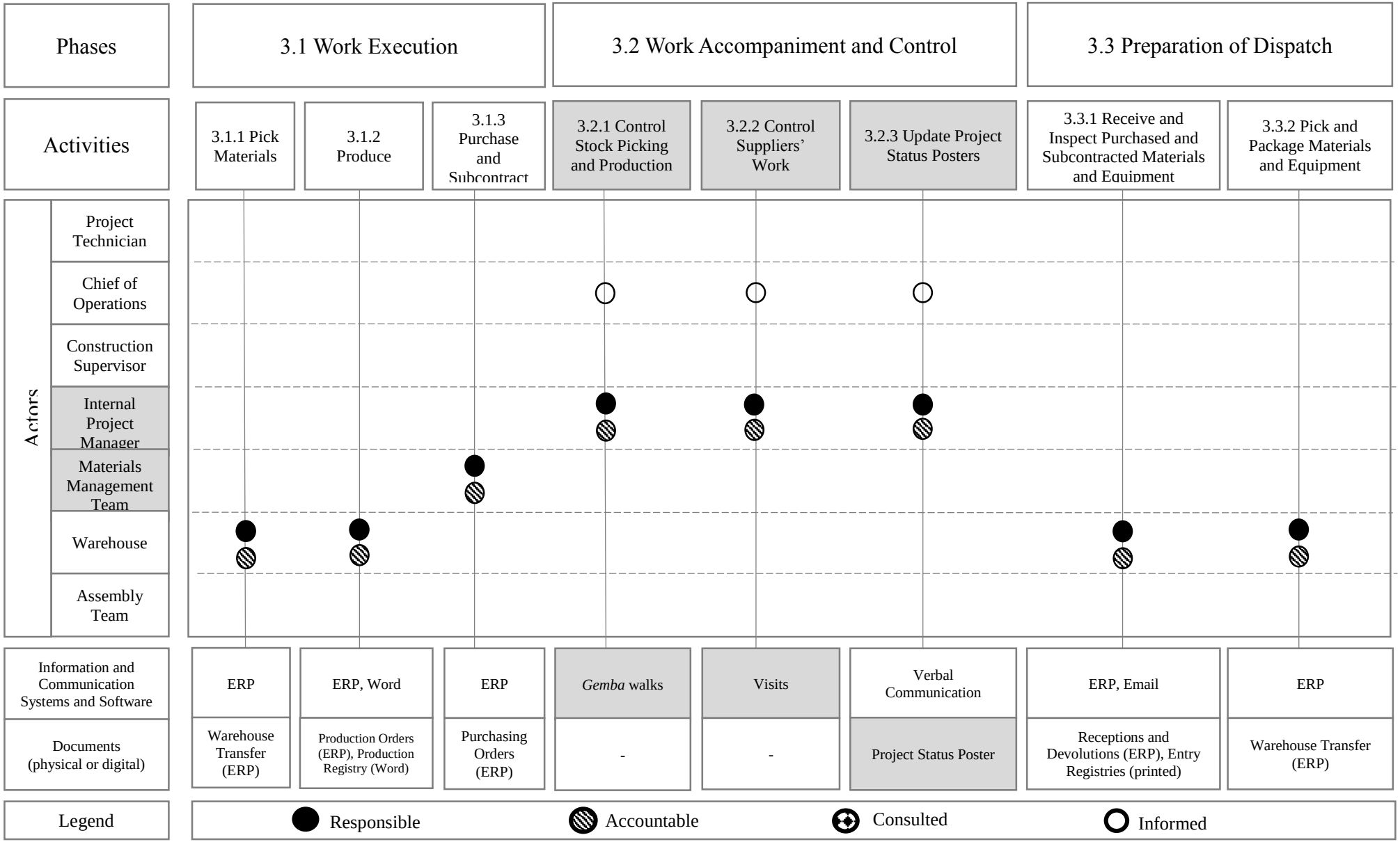
ANNEX AA: To-Be Responsibility Matrix – Process 1.0 Elaborate Proposal



ANNEX AB: To-Be Responsibility Matrix – Process 2.0 Prepare and Plan Work



ANNEX AC: To-Be Responsibility Matrix – Process 3.0 Execute and Control Work



ANNEX AD – KPI for the Work Group Level

Core Process	KPI	Cause/Effect	Frequency	Responsible for Measuring
1.0 Elaborate Proposal	Budget requests with missing information (%)	Cause	Weekly	Director of Estimators' Department
	Proposal reports with missing information (%)			Project Technicians' Leader
	Budgets approved at the first attempt (%)	Effect	Monthly	Director of Estimators' Department
	Rectified Budgets (%) *			
	Budgets with delay (%)			
	Modified Proposal Reports (%)			
2.0 Prepare and Plan Work	Assigned tasks on post-its with delay (%)	Cause	Daily	Internal Project Manager
	Rectified technical treatments (%) *	Effect	Monthly	Project Technicians' Leader
	Technical treatments with delay (%)			
	Rectified materials management processes (%) *			Materials Management's Leader
3.0 Prepare and Plan Work	Suppliers' problems that were detected by internal project manager (%)	Cause	Weekly	Materials Management's Leader or Chief of Operations
	Warehouse/production problems that were detected by internal project manager (%)			
	Projects in which suppliers have failed (%)	Effect	Monthly	Materials Management's Leader
	Defective production orders (%)			Warehouse Leader
	Wrongly separated material (%)			
	Defective suppliers' receptions that were detected by warehouse employees (%)			
4.0 Dispatch and Install Project	Allocation that led to material danification (%)	Effect	Monthly	
	Transportation that led to material danification (%)			
	Projects with problems detected at the construction site (%)*			Construction Supervisor
	Projects that met the dispatch date (%)			
	Projects that met the finalization date (%)			

ANNEX AE – KPI for the Management Level

KPI	Frequency	Responsible for Measuring	Employee being evaluated
Attended monthly change committee reunions (%)	Quarterly	Leader of Change Committee	Member of Change Committee
Attended weekly reunions between the work group leader and the member of the change committee responsible for the work group (%)	Monthly	Leader of Change Committee	Work group champion
Performed daily reunions (%)	Weekly	Work group champion	Work group leader
Budget requests/Projects that did not respect the corresponding *Kanban* system (%)	Weekly	Work group champion	Work group leader
Change project deliverables that met the corresponding deadline (%)	Monthly	Work group champion	Work group leader

ANNEX AF – Implementation Matrix

Dimension / Project	Relevance	Time	Cost	Interfaces	Risk
A More Adequate Organizational Structure					
A More Visual Office Layout					
A More Effective Problem Solving Method					
A New Approach to Process Management					
A Better Control of Demand and Stocks					
A More Adequate Approach to the Technological Support